COLORADO

Department of Public Health & Environment

Exceptional Event Demonstration for O_3 During September 2-4, 2017

Prepared by the

Air Pollution Control Division

Colorado Department of Public Health and Environment

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Executive Summary

The Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) identified that wildfires in the northwestern United States caused ozone (O_3) exceedances at four O_3 monitoring sites on September 2, 2017 and six O_3 monitoring sites on September 4, 2017 in Colorado. These two events are sourced to smoke from numerous wildfires fires in the northwestern United States, particularly from a few very large fires in Idaho and western Montana, which transported smoke to the southeast and increased O_3 concentrations in the northern Front Range region of Colorado. Under the Clean Air Act (CAA), the Exceptional Events Rule (EER) allow the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances of the national ambient air quality standards (NAAQS). This document provides a description of the events, an overview of the EER, and the regulatory significance of this demonstration. In addition, the following information presented in this document satisfies all of the EER criteria and includes:

Table 1: Summary of APCD demonstration based on EER Requirements

EER Requirement	Section	Summary
Narrative Conceptual Model	3	The narrative conceptual model describes the affected area, meteorological conditions of the region and the source causing the exceedances. It includes a discussion of how emissions from the wildfires led to the exceedances in relation to the chemistry of event and non-event O_3 formation in the area.
Clear causal relationship	4	The wildfires affected air quality in such a way that there exists a clear causal relationship between the wildfires and the monitored exceedances. This section includes the following: evidence that the wildfires emissions were transported to the monitors; evidence that emissions from the wildfires influenced the monitored concentrations; quantification of the wildfires emissions contributing to the monitored O_3 exceedances, and; a comparison of O_3 data

		requested for exclusion against historical O_3 concentrations at the affected monitors.
Natural event or caused by human activity that is unlikely to recur	5	The natural event or human activity that is unlikely to recur requirement is met by demonstrating that the events meet the EER definition of wildfire. APCD provides evidence that the wildfires were natural events, none of the wildfires were caused by human activity, and they occurred on wildland.
Not reasonably controllable or preventable	6	The not reasonably controllable or preventable requirement is met by demonstrating that the wildfires were natural events and occurred on wildland.
Procedural requirements	7	APCD met EER procedural requirements for flagging, demonstration, and public comment as summarized in this section.

The APCD is requesting concurrence on exclusion of the NAAQS exceedances monitored O_3 values from Table 2 in that they meet the criteria in the EER as summarized in Table 1.

Table 2: Daily Maximum 8-hour O3 Concentrations for the Exceptional Event

Site Name AQSID	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**	**0.073 ppm**	**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**

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Acronyms

AGL	Above ground level
AOD	Aerosol Optical Depth
APCD	Air Pollution Control Division
AQS	Air Quality System
AQSI	Air Quality System Identifier
CAA	Clean Air Act
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
CO	Carbon Monoxide
DJ	Denver-Julesburg
DM/NFR	Denver Metro/North Front Range
EER	Exceptional Event Rule
EPA	Environmental Protection Agency
°F	Degrees Fahrenheit
FRM	Federal Reference Method
GDAS	Global Data Assimilation System
HMS	Hazard Mapping System
HRRR	High-Resolution Rapid Refresh
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
IR	Infrared
mb	Millibar
MODIS	Moderate Resolution Imaging Spectroradiometer
MST	Mountain Standard Time
NAAQS	National Ambient Air Quality Standards
NAM	North American Model
NOAA	National Oceanic and Atmospheric Administration
NO_x	Oxides of Nitrogen
NPS	National Park Service
NREL	National Renewable Energy Laboratory
NWS	National Weather Service
O_3	Ozone
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter less than or equal to 2.5 microns in aerodynamic diameter
PM_{10}	Particulate Matter less than or equal to 10 microns in aerodynamic diameter
ppb	Parts Per Billion
ppm	Parts Per Million
RFN	Rocky Flats North
SIP	State Implementation Plan

1.0 Overview

The APCD has determined that O_3 concentrations exceeding the NAAQS on September 2 and 4, 2017 qualify as an exceptional event under Title 40, Part 50 of the Code of Federal Regulations (CFR), the revised EER. The purpose of this document is to provide technical documentation to support a concurrence and petition the Regional Administrator for Region 8 of the U.S. Environmental Protection Agency (EPA) to exclude air quality monitoring data for O_3 from the normal planning and regulatory requirements under the CAA in accordance with the EER. This exceptional event demonstration underwent public review and comment before submittal (see Section 7).

1.1 Event Summary and Related Concentrations

On September 2 and September 4, 2017, the APCD monitored three exceedances of the 2008 0.075 ppm 8-hour O_3 NAAQS and 10 exceedances of the 2015 0.070 ppm (parts per million) 8-hour O_3 NAAQS, with concentrations reaching 0.076 ppm and 0.078 ppm on September 2 and September 4, respectively. These elevated concentrations were a result of wildfire smoke which contained O_3 precursors from numerous wildfires in the Pacific Northwest, Wyoming, Idaho and Montana that were transported into to Colorado's Denver Metro/Northern Front Range (DM/NFR) on prevailing winds. With respect to the 2008 0.075 ppm 8-hour O_3 NAAQS, these elevated O_3 concentrations resulted exceedances at the Rocky Flats North (RFN) site on September 4, 2017, and the National Renewable Energy Laboratory (NREL) site on both September 2 and 4, 2017. Elevated $PM_{2.5}$ concentrations support the presence of wildfire smoke; this significance is further described in the historical significance section below.

1.2 Exceptional Event Rule Summary

EPA promulgated the EER in 40 CFR Parts 50 and 51 on March 22, 2007 (72 FR 13560), pursuant to the 2005 amendment of CAA section 319(b), which allows for the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of NAAQS, provided that:

1. The occurrence of an exceptional event must be demonstrated by reliable, accurate data that is promptly produced and provided by Federal, State, or local government agencies;

2. A clear causal relationship must exist between the measured exceedances of a national ambient air quality standard and the exceptional event to demonstrate that the exceptional event caused a specific air pollution concentration at a particular air quality monitoring location;
3. There is a public process for determining whether an event is exceptional, and;
4. There are criteria and procedures for the Governor of a State to petition the Administrator to exclude air quality monitoring data that is directly due to exceptional events from use in determinations by the Administrator with respect to exceedances or violations of the national ambient air quality standards.

The 2016 EER revisions added sections 40 CFR 50.1(j)-(r), 50.14, and 51.930. The EER as defined in 40 CFR 50.14 states that "…a State that has flagged data as being flagged due to an exceptional event and is requesting exclusion of the affected measurement data shall, after notice and opportunity for public, submit a demonstration to justify data exclusion to the Administrator according to the schedule established under paragraph (c)(2)(i)(B)." Per 40 CFR 50.14(c)(3)(iv)(A)-(E), the demonstration to justify data exclusion must include:

1. A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s);
2. A demonstration that the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation;
3. Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times to support the requirement at paragraph (c)(3)(iv)(B) of this section. The Administrator shall not require a State to prove a specific percentile point in the distribution of data;
4. A demonstration that the event was both not reasonably controllable and not reasonably preventable, and;
5. A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event.

With respect to wildfires, 40 CFR 50.14(b)(4) states that "The Administrator shall exclude data from use in determinations of exceedances and violations where a State demonstrates to the Administrator's satisfaction that emissions from wildfires caused a specific air pollution concentration in excess of one or more national ambient air quality standard at a particular air quality monitoring location and otherwise satisfies the requirements of this section. Provided the Administrator determines that there is no compelling evidence to the contrary in the record, the Administrator will determine every wildfire occurring predominantly on wildland to have met the requirements identified in paragraph (c)(3)(iv)(D) of this section regarding the not reasonably controllable or preventable criterion." In addition, the air agency must meet several procedural requirements, including:

1. Submission of an Initial Notification of Potential Exceptional Event and flagging of the affected data in EPA's Air Quality System (AQS) as described in 40 CFR 50.14(c)(2)(i), and;
2. Completion and documentation of the public comment process described in 40 CFR 50.14(c)(3)(v).

1.3 Demonstration Outline

The EPA Guidance on the Preparation of Exceptional Event Demonstrations for Wildfire Events that May Influence Ozone Concentrations, hereafter referred to as "Guidance", provides recommendations for the preparation and submission of exceptional event demonstrations for wildfire influences on O_3 (EPA, 2016). The Guidance was used to create the following outline for this demonstration:

- Regulatory Significance: the exceptional events rule applies to regulatory actions in CAA section 319, including area designations and redesignations; area classifications; attainment determinations; attainment date extensions; findings of State Implementation Plan (SIP) inadequacy leading to a SIP call; and other provisions as stated in 40 CFR 50.14(a)(1)(i).
- Narrative Conceptual Model: 40 CFR 50.14(c)(3)(iv)(A) requires the inclusion of a narrative conceptual model that describes the event; the interaction of emissions, meteorology, and chemistry of event and non-event O_3 formation in the area, and; the regulatory significance of the proposed data exclusion.
- Clear Casual Relationship and Supporting Analysis: 40 CFR 50.14(c)(3)(iv)(B)-(C) requires a technical description of the relationship between the specific event and the monitored exceedance. This includes a comparison of historical O_3 concentrations at the air quality monitor and data requested for exclusion. The Guidance recommends

use of a tiered analysis to address the clear causal relationship element within a demonstration (see Table 3). In preparation of this demonstration, the APCD and the EPA agreed that the event qualifies for Tier 2 causal analyses.

Table: 3 Summary of Tiered Analysis

Tier 1	Tier 2	Tier 3
Wildfires that clearly influence monitored O_3 exceedances or violations when they occur in an area that typically experiences lower O_3 concentrations. This tier is associated with an O_3 concentration that is clearly higher than non-event related concentrations, or occur outside of the area's normal O_3 season.	The wildfire event's O_3 influences are higher than non-event related concentrations, and fire emissions compared to the fire's distance from the affected monitor indicate a clear causal relationship.	The wildfire does not fall into the specific scenarios that qualify for Tier 1 or Tier 2, but the clear causal relationship criterion can still be satisfied by a weight of evidence showing.

- Caused by Human Activity that is Unlikely to Recur at a Particular Location or a Natural Event: 40 CFR 50.14(c)(3)(iv)(E) states that a demonstration must establish that the event was caused by "a human activity that is unlikely to recur at a particular location or was a natural event."
- Not Reasonably Controllable or Preventable: 40 CFR 50.14(c)(3)(iv)(D) states that a demonstration must establish "that the event was both not reasonably controllable and not reasonably preventable."
- Public Comment: 40 CFR 50.14(c)(1)(i), air agencies must "notify the public promptly whenever an event occurs or is reasonably anticipated to occur which may result in the exceedance of an applicable air quality standard." In addition, according to 40 CFR 50.14(c)(3)(v), air agencies must "document [in their exceptional events demonstration] that the [air agency] followed the public comment process and that the comment period was open for a minimum of 30 days…." Further, air agencies must submit any received public comments to the EPA and address in their submission those comments disputing or contradicting the factual evidence in the demonstration.

2.0 Regulatory Significance

Per 40 CFR 50.14(a)(1)(i), the EER applies to data showing an exceedance of a standard which may affect regulatory determinations regarding attainment designation status or other action by the Administrator. A site is in violation of the 2008 and 2015 NAAQS 8-hour standards if the monitored design value for that site is in exceedance of 0.075 ppm or 0.070 ppm. The O_3 design value is derived from the 3-year average of the fourth highest 8-hour maximum daily average monitored O_3 level.

The O_3 ambient air monitoring network in the Denver Metro area and along the northern Front Range consists of 14 stations operated by the APCD and one location (two stations) operated by the National Park Service (NPS) and the EPA in Rocky Mountain National Park. On September 2 and September 4, 2017, the APCD monitored three exceedances of the 2008 0.075 ppm 8-hour O_3 NAAQS and 10 exceedances of the 2015 0.070 ppm 8-hour O_3 NAAQS in this area.

On May 4, 2016, the EPA published a final rule that determined Colorado's marginal O_3 nonattainment area failed to attain the 2008 eight-hour O_3 NAAQS by the applicable marginal attainment deadline and therefore was reclassified the DM/NFR area to moderate. This action requires attainment of the NAAQS no later than July 20, 2018 based on 2015-2017 O_3 season data. This exceptional event exclusion will prevent a reclassification in Colorado's DM/NFR O_3 non-attainment area from "moderate" to "serious" under the 2008 O_3 Standard with regard to this three-year dataset (2015-2017). Exclusion of this data may also affect future non-attainment designations under the 2015 O_3 Standard. The APCD requests that the observed data on September 2 and 4, 2017 at the monitors listed in Table 4 be flagged as impacted by an exceptional event and excluded from regulatory use.

Table 4: Daily Maximum 8-hour O_3 Concentrations for the Exceptional Event

Site Name AQSID	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**	**0.073 ppm**	**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**

3.0 Narrative Conceptual Model

3.1 Regional Description

3.1.1 Monitor Descriptions: O_3 Monitoring Network

The CDPHE-APCD operates a network of regulatory O_3 sites throughout Colorado, with most focused in the North Front Range O_3 non-attainment area. In addition, the NPS operates a regulatory site in Rocky Mountain National Park. These regulatory sites meet the U.S. EPA quality assurance criteria as outlined in the U.S. CFR, Title 40, Part 58, Appendix A. A list of these DM/NFR area sites is presented in Table 5 and in a map in Figure 1. Other non-regulatory O_3 monitors are operated in Colorado by the APCD and the National Oceanic and Atmospheric Administration (NOAA), but are not listed in this document.

Table 5: 2017 DM/NFR O_3 Monitoring Sites (regulatory)

AQS #	Site Name	Address	County	Elev. (m)	Latitude	Longitude
08 001 3001	Welby	3174 E. 78th Ave.	Adams	1,554	39.838119	-104.949840
08 005 0002	Highland Reservoir	8100 S. University Blvd.	Arapahoe	1,747	39.567887	-104.957193
08 005 0006	Aurora - East	36001 E. Quincy Ave.	Arapahoe	1,552	39.63854	-104.56913
08 013 0014	Boulder Reservoir	5565 N. 51st St.	Boulder	1,586	40.070016	-105.220238
08 031 0002	CAMP	2105 Broadway	Denver	1,593	39.751184	-104.987625
08 031 0026	La Casa	4587 Navajo St.	Denver	1,594	39.779429	-105.005174
08 031 0027	I-25 Denver	971 Yuma Street	Denver	1,586	39.732146	-105.015317
08 035 0004	Chatfield State Park	11500 Roxborough Pk. Rd.	Douglas	1,676	39.534488	-105.070358
08 059 0005	Welch	12400 W. Hwy. 285	Jefferson	1,742	39.638781	-105.139480
08 059 0006	Rocky Flats - N	16600 W. Hwy. 128	Jefferson	1,802	39.912799	-105.188587
08 059 0011	NREL	2054 Quaker St.	Jefferson	1,832	39.743724	-105.177989
08 059 0013	Aspen Park	26137 Conifer Rd.	Jefferson	2,467	39.540321	-105.296512
08 069 0007	Rocky Mountain NP	Preservation Dr.	Larimer	2,748	40.278145	-105.545660
08 069 0011	Fort Collins - West	3416 La Porte Ave.	Larimer	1,571	40.592543	-105.141122
08 069 1004	Fort Collins - Mason	708 S. Mason St.	Larimer	1,524	40.577470	-105.078920
08 123 0009	Greeley - Tower	3101 35th Ave.	Weld	1,484	40.386368	-104.737440

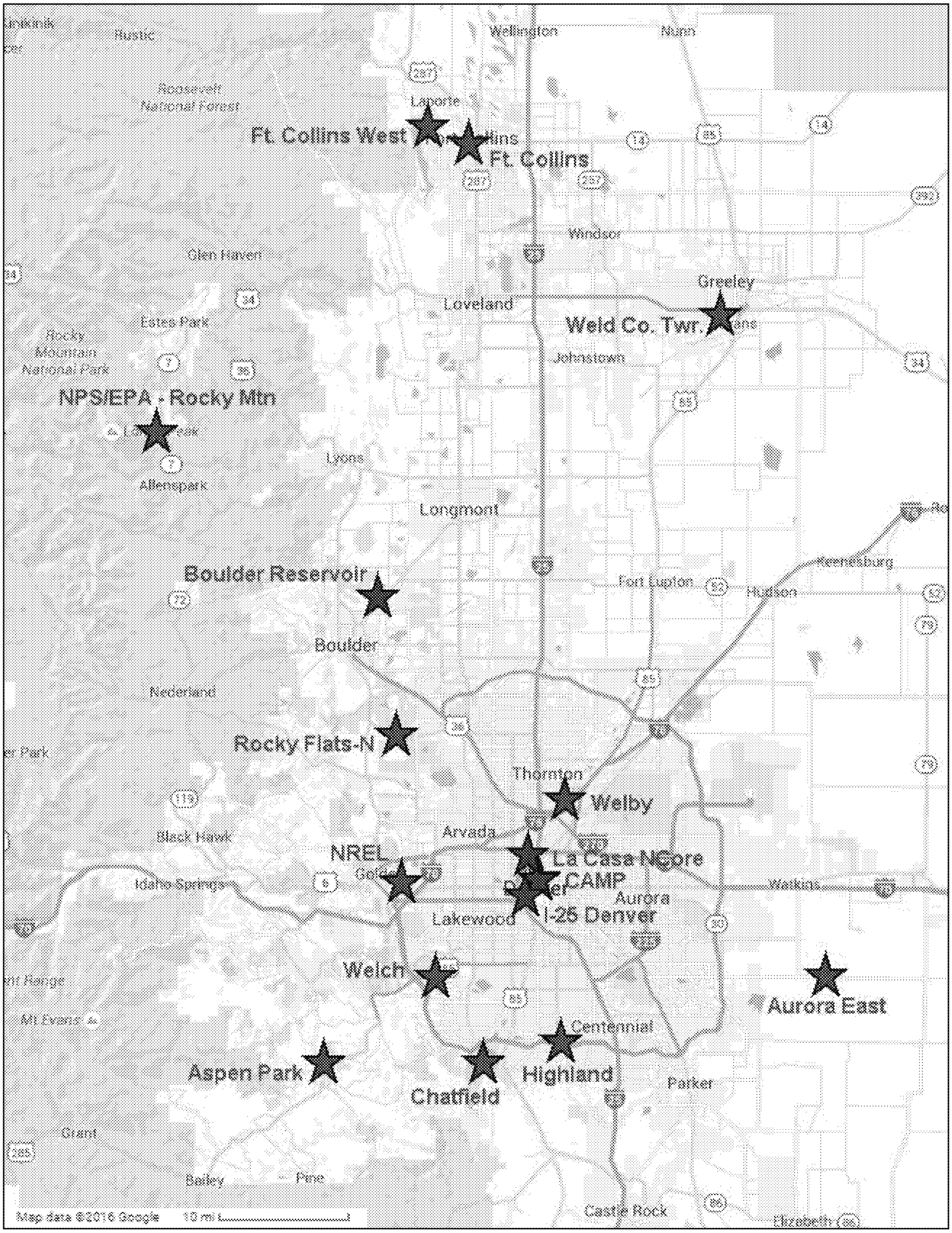


Figure 1: 2017 North Front Range Area O_3 Monitoring Sites (regulatory)

3.1.2 Area Climate: Seasons and Summertime Weather

Colorado's O_3 season is currently defined as year-round in 40 CFR, Part 58, Appendix D. Prior to the 2015 NAAQS O_3 standard, it was set as March 1 to September 30. The typical summer high O_3 season for the DM/NFR area is from May through September when hot days and abundant sunlight are common. Table 6 provides a summary of average high and low temperatures for Denver, as well as average precipitation.

During the summer period, precipitation is primarily related to afternoon thunderstorms. These can be intense and the associated cloud cover prevents O_3 from forming. Is it typical for O_3 levels to increase until afternoon clouds build, then quickly decline due to thunderstorms. As these thunderstorms are often isolated, one part of the DM/NFR area may be impacted while O_3 formation continues in another area.

Table 6: Average Temperatures and Precipitation for Denver, 1981 - 2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. high temp in °F:	45	46	54	61	72	82	90	88	79	66	52	45
Avg. low temp in °F:	18	19	27	34	43	52	59	57	48	37	25	18
Avg. precip. in inches:	0.39	0.35	0.91	1.69	2.13	1.97	2.17	1.69	0.94	1.02	0.59	0.31

Source: www.usclimatedata.com

3.2 Characteristics of Non-Event O_3 Formation

3.2.1 Non-Event Weather Patterns

High O_3 concentrations events are typically associated with specific meteorological conditions that favor optimal O_3 photochemistry and limited dispersion. A recent paper that explores the relationships between meteorology and O_3 concludes that increases in upper level high pressure strength "lead to high July O_3 in much of the western U.S., particularly in areas of elevated terrain near urban sources with high emissions of NO_2 and other O_3 precursors. In addition to bringing warmer temperatures, upper level ridges in this region reduce westerlies at the surface and aloft and allow cyclic terrain-driven circulations to reduce transport away from sources. Upper level ridges can also increase background concentrations within the ridge. O_3 and NO_2 concentrations build locally, and deeper vertical mixing in this region provides a potential mechanism for recapture of O_3 in layers aloft... O_3 precursors and reservoir species in large-scale basin drainage flows can be brought back to source areas and nearby mountains by daytime, thermally driven upslope flows" (Reddy and Pfister, 2016).

The key elements of a conceptual model for high-concentration episodes along the Front Range include:

- The presence of an upper-level high pressure system or ridge;
- Reduced westerly winds, especially during the day; and
- Thermally-driven upslope flow towards the Continental Divide during the day and downslope drainage flows into the Platte Valley at night. This diurnal cycle of winds enhances the potential for the accumulation of O_3 precursors and O_3 within the region, especially when this cyclic pattern recurs over a period of days.

Figure 2 provides a conceptual map of upslope daytime thermally-driven winds for the DM/NFR area. In contrast, downslope nighttime drainage flows are the opposite. Figure 3 examines four typical summer high O_3 days and compiled Hybrid Single-Particle Lagrangian Integrated (HYSPLIT) back-trajectories to look at potential O_3 precursor source areas. As can be seen, for summer non-event high O_3 days, air flows follow the pattern presented in the conceptual model in Figure 2. For non-event days, the Fort Collins West site is primarily influenced by flows that are from the southeast which includes the Denver-Julesburg (DJ) Basin oil and gas region. For the RFN and Chatfield Reservoir sites, airflows from the east-north east to northeast prevail, which includes the DJ Basin oil and gas region as well as the Denver metropolitan area.

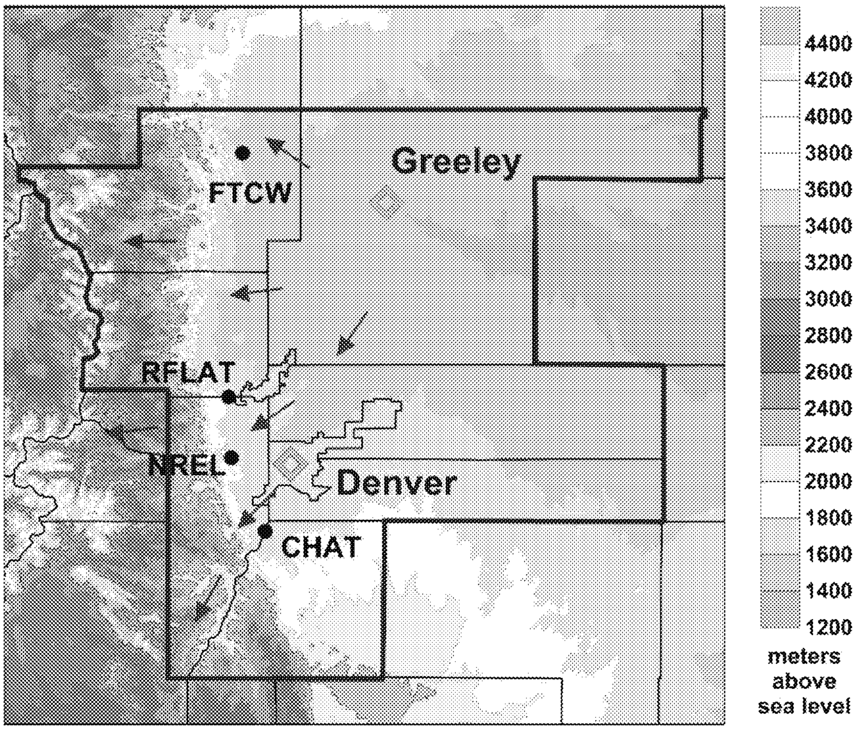


Figure 2: Daytime Thermally-Driven Upslope Flows (red arrows) Toward Higher Terrain

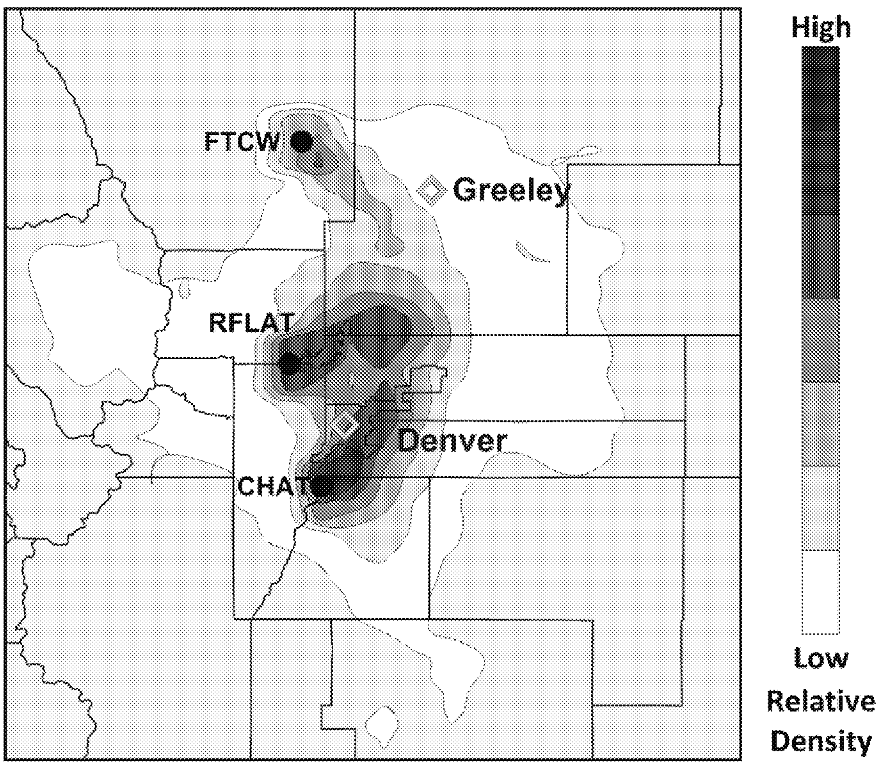


Figure 3: Source Regions for Four Highest 8-hour Concentrations Based on Relative Densities of 24-hour NOAA HYSPLIT Back Trajectories

3.2.2. NO_x and VOC Emissions

Detailed emission inventories were developed for the 2016 DM/NFR Moderate Bump-Up SIP, including volatile organic compounds (VOC's) and oxides of nitrogen (NO_x). Simplistically, summertime O_3 is formed from a chemical reaction between VOC's and NO_x in the presence of sunlight. Thus, VOC's and NO_x are key O_3 precursors and critical elements towards any O_3 formation chemistry and modeling efforts. Table 7 provides a summary of the 2011 inventory and projected 2017 inventory, listing key source categories.

Table 7: Emissions Inventory for the DM/NFR O_3 Non-Attainment Area

Source Sector	VOC (tons/day)		NO_x (tons/day)	
	2011	2017	2011	2017
Oil and Gas - *TOTAL*	***279.7***	***154.0***	***41.4***	***65.8***
Point	14.8	16.3	18.1	20.6
Condensate tanks	216.0	78.7	1.1	0.6
Area	48.9	59.0	22.2	44.6
Point (non O&G) - *TOTAL*	***26.5***	***28.4***	***60.7***	***40.1***
Electric generating units	0.7	0.4	39.7	19.2
Point (non-oil & gas)	25.9	28.0	21.0	20.9
Area (non O&G) - *TOTAL*	***60.6***	***67.5***	***0.0***	***0.0***
Non-Road Mobile - *TOTAL*	***58.2***	***44.3***	***75.9***	***54.9***
On-Road Mobile - *TOTAL*	***93.7***	***55.0***	***142.0***	***73.3***
Light duty vehicles	90.0	52.4	102.5	50.3
Medium/heavy duty vehicles	3.7	2.6	39.6	23.0
Biogenic Sources - *TOTAL*	***170.5***	***6.1***	***170.5***	***6.1***
TOTAL Anthropogenic Emissions	***518.8***	***349.2***	***320.0***	***234.0***

Source: Moderate Area O_3 SIP for the Denver Metro and North Front Range Nonattainment Area, 2016

In Table 7, oil and gas is by far the dominant source sector for VOC's, followed by on-road mobile sources (highway vehicles). Most oil and gas development in the North Front Range area is in the DJ Basin, to the northeast of Denver in Weld County. In contrast, on-road and non-road mobile sources dominate the NO_x inventory. Most of these emissions occur in the Denver metropolitan area.

3.2.3 Non-Event Historical O_3 Concentrations

To illustrate historical non-event max daily 8-hour average O_3 observations in the region, both monthly historical data and data from a two week window surrounding September 2 and 4, 2017 are present here.

Non-event data from the month of September range from 2011 to 2016, with all days that were suspect of exceptional events flagged and removed from this analysis. The exception to this is data from the Highlands site where construction at the site prohibited the collection of O_3 data from October 2013 through August 2015. Historical evaluations of the Highland data are made with a smaller sample size than other sites. Descriptive statistics for the historical data for September is presented in Table 8, all data values are presented in ppm.

Table 8: Summary of September Non-Event Max Daily 8-hour Average O_3 Data (2011-2016)

Summary of Maximum Daily 8-hour Average O_3 ppm for September 2011-2016						
Evaluation	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
Mean	0.047	0.051	0.049	0.051	0.052	0.046
Median	0.047	0.051	0.050	0.051	0.052	0.047
Mode	0.048	0.056	0.052	0.056	0.046	0.046
St. Dev.	0.008	0.010	0.009	0.010	0.011	0.010
Minimum	0.023	0.017	0.020	0.016	0.018	0.014
99 %ile	0.066	0.071	0.070	0.071	0.078	0.069
Maximum	0.068	0.081	0.073	0.072	0.079	0.071
Range	0.045	0.064	0.053	0.0561	0.061	0.057
Count	172	179	146	177	176	176

Since September is a transitional month from peak O_3 season, a more complete picture framing the historical context of the first few days in September may be elucidated examining the two weeks surrounding September 2 and 4. Here, historical non-event max daily 8-hour average O_3 data begins on August 26 and end on September 9 for the years 2011 to 2016 (a week before and after the September 2 and 4 events), with the exception of the Highlands data as described. The descriptive statistics for this historical data is presented in Table 9, all data values are presented in ppm.

Table 9: Summary of 2-Week Non-Event Max Daily 8-hr Average O_3 Data (August 26 to September 9, 2011-2016)

Comparison of Event Data 2-Week Non-Event Historical Summary Data						
Evaluation	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
Mean	0.051	0.056	0.057	0.056	0.057	0.052
Median	0.050	0.055	0.059	0.058	0.058	0.053
Mode	0.050	0.063	0.059	0.059	0.064	0.049
St. Dev.	0.009	0.011	0.009	0.010	0.010	0.010
Minimum	0.032	0.030	0.041	0.029	0.030	0.026
95 %tile	0.067	0.074	0.074	0.072	0.071	0.070
99 %tile	0.073	0.082	0.080	0.076	0.078	0.074
Maximum	0.080	0.086	0.085	0.084	0.079	0.080
Range	0.048	0.056	0.044	0.055	0.049	0.054
Count	81	87	68	90	86	89

3.3 Characteristics of Event O_3 Formation

3.3.1 Event O_3 and $PM_{2.5}$ Measurements

Elevated O_3 was observed at a number of APCD monitors on September 2 and 4, 2017. Table 10 lists daily maximum 8-hour average O_3 concentrations across the DM/NFR air monitoring network for August 30, 2017 through September 7, 2017.

Table 10: Daily 8-hour Daily Max O_3 Concentrations (ppm) - DM/NFR Sites

Date	Aspen Park	Aurora East	Boulder Reservoir	CAMP	Chatfield	La Casa	Fort Collins CSU	Fort Collins West	Greeley	Highlands	Mines Peak	NREL	Rocky Flats North	Welby	Welch
8/30/17	0.057	0.058	0.061	0.056	0.069	0.058	0.061	0.076	0.072	0.062	0.057	0.068	0.068	0.056	0.069
8/31/17	0.051	0.060	0.062	0.049	0.059	0.052	0.039	0.056	0.062	0.060	0.052	0.059	0.061	0.054	0.056
9/1/17	0.054	0.058	0.056	0.051	0.062	0.053	0.046	0.056	0.053	0.059	0.053	0.061	0.061	0.054	0.057
9/2/17	0.056	0.068	0.066	0.067	0.071	0.069	0.059	0.069	0.066	0.070	0.062	0.076	0.071	0.066	0.075
9/3/17	0.058	0.060	0.054	0.055	0.064	0.053	0.047	0.055	0.055	0.062	0.058	0.060	0.059	-	0.061
9/4/17	0.072	0.068	0.067	0.069	0.073	0.069	0.054	0.061	0.065	0.071	0.070	0.076	0.078	-	0.074
9/5/17	0.042	0.042	0.046	0.037	0.048	0.039	0.041	0.051	0.045	0.044	0.066	0.048	0.049	0.040	0.042
9/6/17	0.062	0.059	0.072	0.058	0.066	0.062	0.057	0.068	0.061	0.061	0.070	0.073	0.075	0.061	0.065
9/7/17	0.062	0.064	0.067	0.054	0.071	0.055	0.056	0.070	0.061	0.067	0.066	0.068	0.071	0.060	0.061

Note – Gray shading indicates exceptional event days
Note - Yellow shading indicates exceedance of the 2008 0.075 ppm O_3 NAAQS on exceptional event days only
Note – Blue shading indicates exceedance of the 2015 0.070 ppm O_3 NAAQS on exceptional event days only
Note - No O_3 data reported for Welby on 9/4/2017 due to a analyzer malfunction

Note – In this exceptional event demonstration, the APCD is requesting to exclude all hourly O_3 data from all Northern Front Range sites for September 2 00:00 to 23:59 MST and September 3, 00:00 to 23:59 MST. Exclusion of the data caused by this exceptional event, will in part, have a regulatory impact on Colorado's non-attainment re-classification from "moderate" to "serious" under the 2008 O_3 Standard.

This event-driven episodic increase in O_3concentrations is seen in Figure 4, as a time series of measurements from monitoring sites which exceeded the 0.70 ppm 2015-NAAQS standard during this period and correlate in time with nearby $PM_{2.5}$ measurements. Figure 4 shows two stacked time series graphs for data from select DM/NFR O_3 sites (top) and continuous $PM_{2.5}$ sites (bottom) for dates approximately seven days before and following the September 2 event. The red boxes on the graph delineate the 24-hour period of the September 2 and September 4, 2017 O_3 exceedance events. Using $PM_{2.5}$ as an indicator for wildfire smoke, these graphs demonstrate the presence of smoke, supporting that wildfire smoke contributed to the elevated O_3 concentrations observed at many monitoring locations along the DM/NFR.

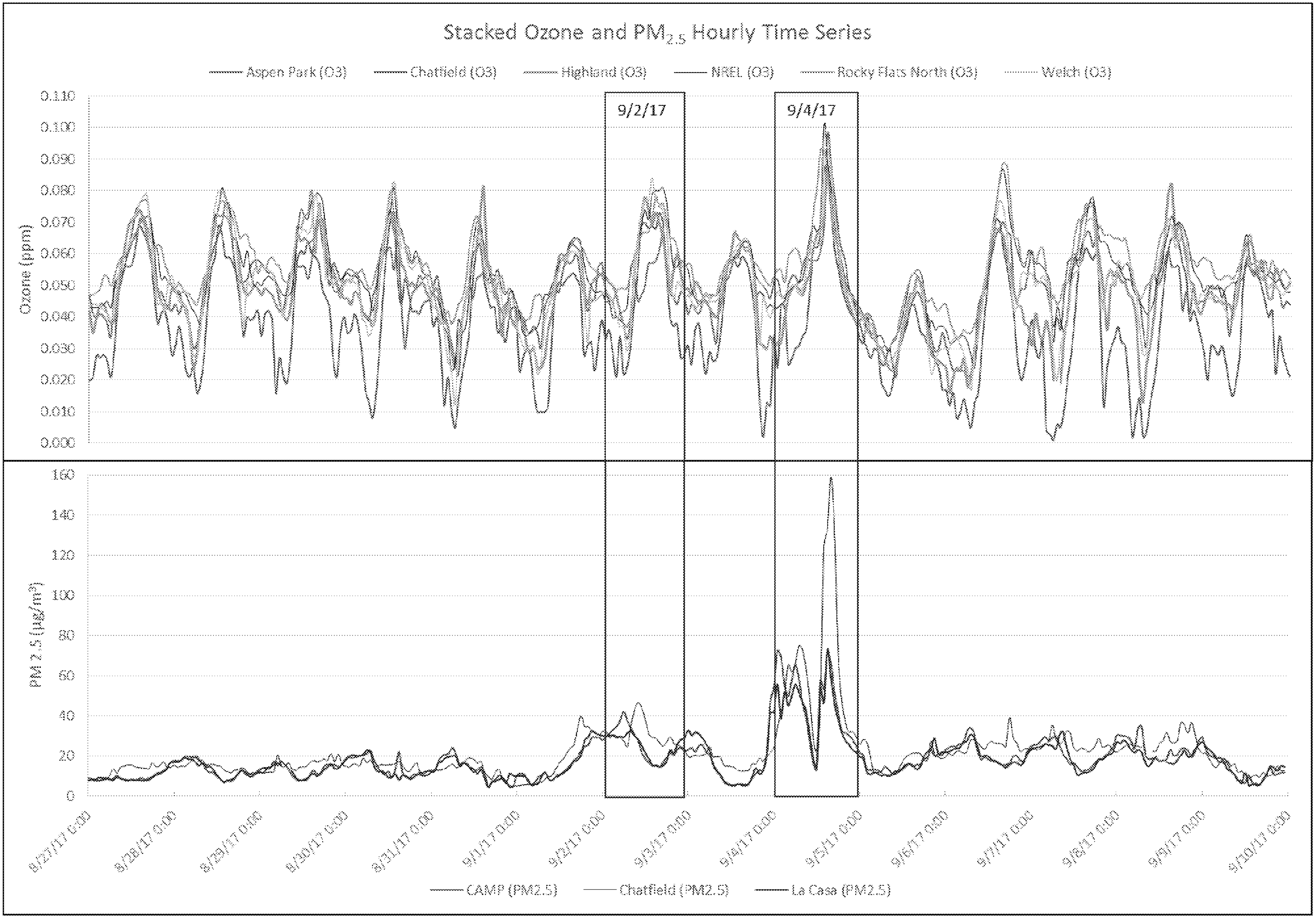


Figure 4: Stacked O_3 and $PM_{2.5}$ Hourly Time Series

3.3.2 Summary of Meteorological Conditions during Episode

An extended period of dry conditions across the western U.S. coupled with elevated temperatures and localized breezy winds created an environment conducive to dangerous fire weather and fire development during the first few days of September 2017. Washington, Oregon, Idaho, and Montana received very little precipitation during the two months prior to the event, with most areas in these states receiving less than 0.5 inches of rain as presented in Figures 5 and 6. Idaho and Montana experienced warmer than average temperatures by 4-10°F above normal in July 2017, and Washington and Oregon experienced warmer than average temperatures by 4-10°F above normal in August 2017 as seen in Figures 7 and 8. Low precipitation and warm temperatures contributed to abnormally dry to exceptional drought conditions in the months leading up to this episode. Figure 9 illustrates the Western U.S. drought conditions just a few days prior to the event.

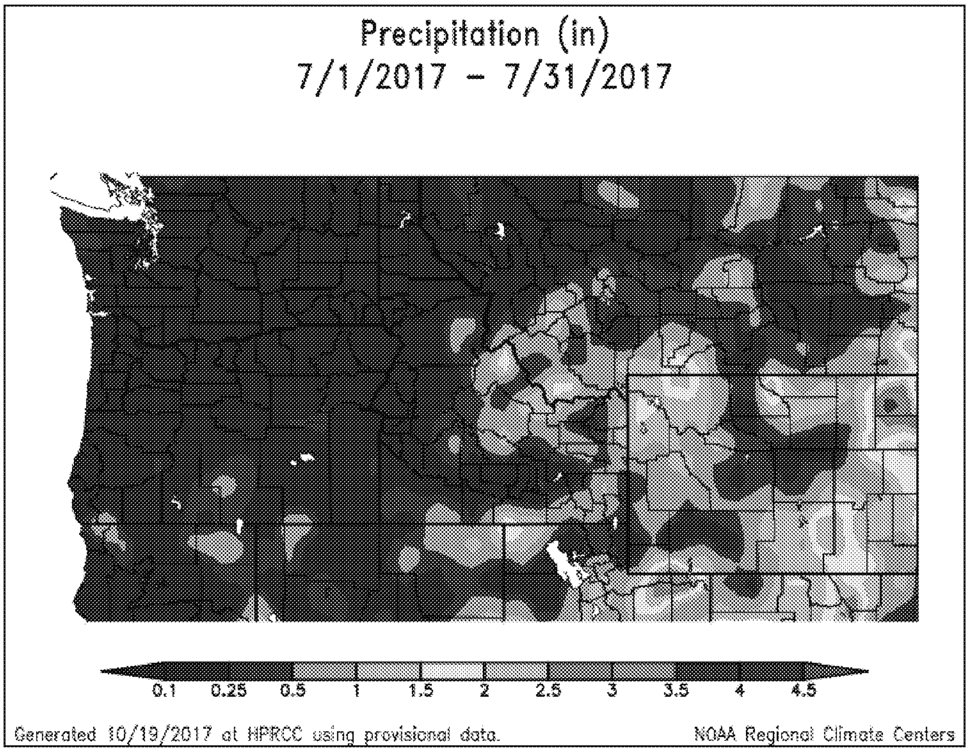


Figure 5: Total precipitation in inches, Western Regional Climate Center, northwest region, July 2017. (source: https://hprcc.unl.edu)

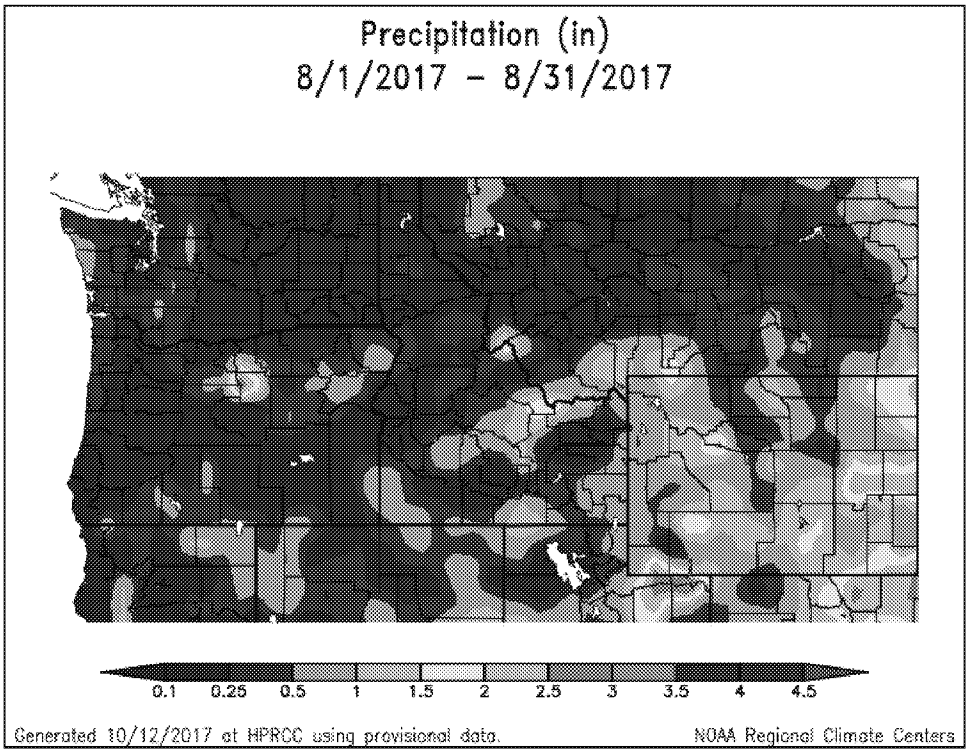


Figure 6: Total precipitation in inches, Western Regional Climate Center, northwest region, August 2017. (source: https://hprcc.unl.edu)

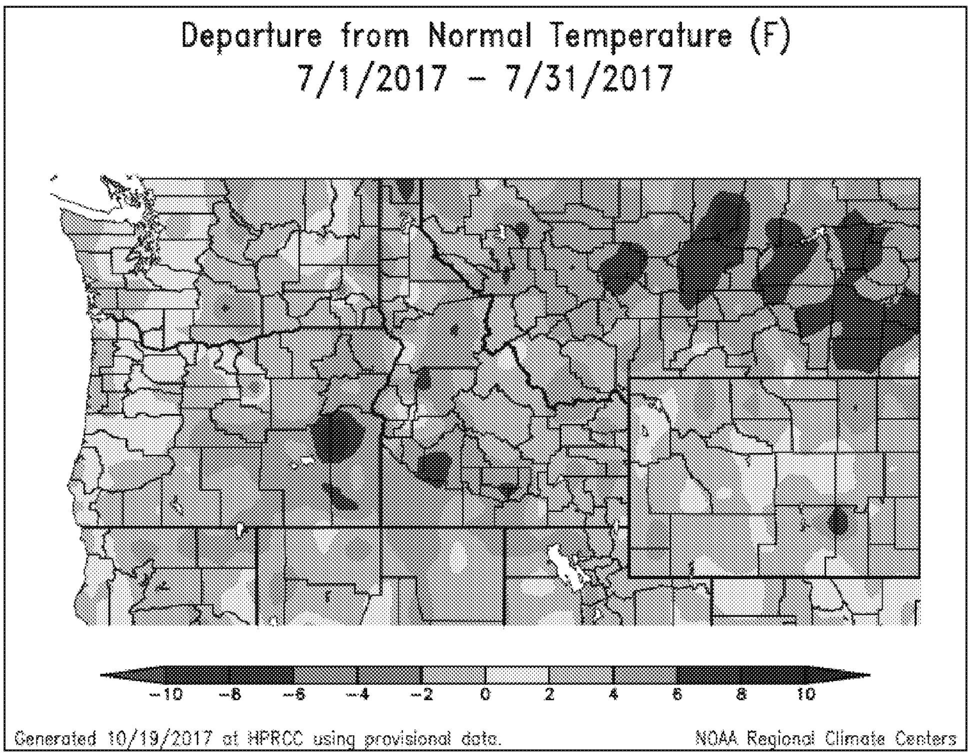


Figure 7: Departure from normal temperature (degrees Fahrenheit), Western Regional Climate Center, northwest region, July 2017. (source: https://hprcc.unl.edu)

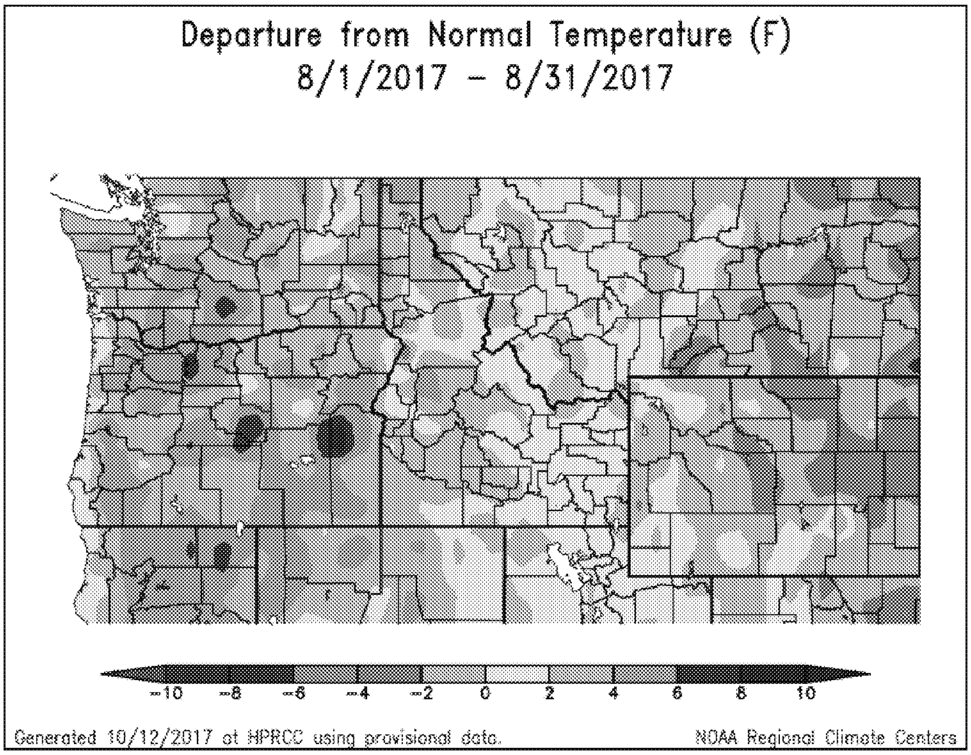


Figure 8: Departure from normal temperature (degrees Fahrenheit), Western Regional Climate Center, northwest region, August 2017. (source: https://hprcc.unl.edu)

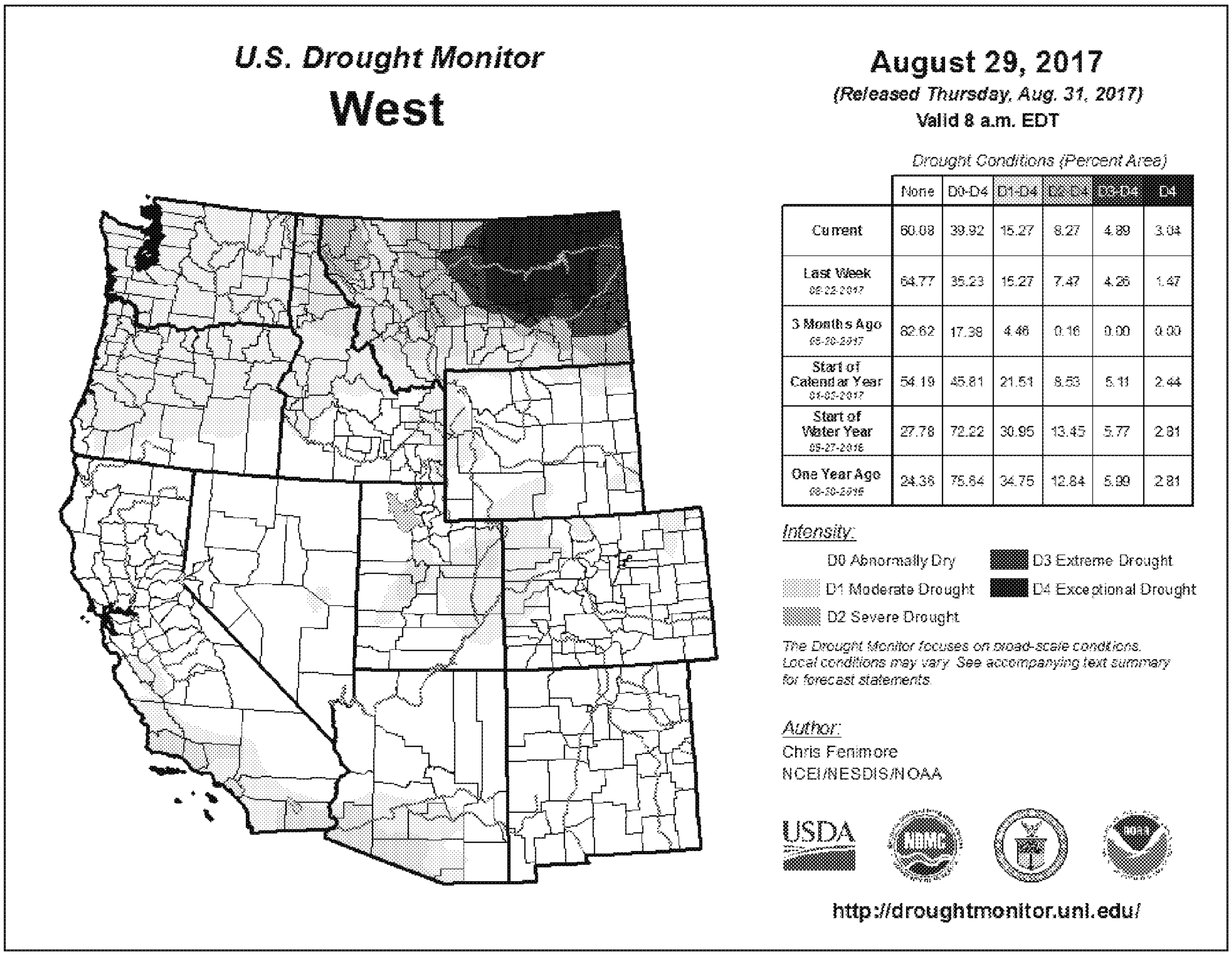


Figure 9: Drought conditions for the western U.S. at 5:00 AM MST August 29, 2017. (source: http://droughtmonitor.unl.edu)

A large upper-level ridge of high pressure centered over the western US is shown on the 500 millibars (mb) height analysis maps starting at 5:00 PM MST (0Z August 31, 2017) on August 30, 2017, and largely persists as shown in sequential maps every 12 hours through 5:00 PM MST (00Z September 5, 2017) on September 4, 2017, in Figures 10a-k. The 500 mb level is located roughly 6 kilometers above mean sea level. Initially, a short-wave trough of low pressure over the Pacific Northwest moved through the predominate ridge on August 31(Figure 10a-b). As this short-wave trough moved eastward the ridge of high pressure re-strengthened over the entire western U.S. during September 1, 2017 (Figures 10c-f), the trough became well established within the upper-level flow, transport, and circulation by September 3, 2017 through September 4, 2017 (Figures 10g-k). Strong and steady west to northwest winds (~50 knots) in the mid to upper levels of the atmosphere acted as a conveyor belt, steering air from the Pacific Northwest and northern Rocky Mountains to the DM/NFR area.

The mid to upper-level wind influence in atmospheric circulation is evident in Moderate Resolution Imaging Spectroradiometer (MODIS) Terra True Color Satellite imagery during August 31 – September 4th, 2017, as seen in Figures 11a-e. Visible smoke from fires in the Pacific Northwest and northern Rocky Mountains region transported during this time period correlated with the mostly persistent 500 mb weather pattern shown in Figure 10.

Although the mid to upper level winds were the primary transport mechanism of wildfire smoke to the Denver Metro Area, surface level winds were also favorable for ground level smoke transport. The surface weather associated with this pattern is presented in Figure 12a-k, with surface analyses starting at 5:00 PM MST (0Z August 31, 2017) August 30, 2017 and progressing every 12 hours through 5:00 PM MST (0Z September 5, 2017) September 4, 2017. A cold front pushed southeast from the Pacific Northwest into Idaho, Montana, and eventually the Dakotas during August 31, 2017 and into September 1, 2017 (Figure 12a-d). By early in the day of September 2, 2017, a stationary front developed over the Montana-Canadian border (Figure 12f). This stationary front gradually transitioned into a cold front as it moved south from Montana and Wyoming late on September 3, 2017, quickly progressing south through eastern Colorado and into Oklahoma by evening on September 4, 2017 (Figure 12i-k). The common theme of the surface pattern during this episode was a fairly persistent west-northwesterly surface wind flow. This allowed air containing heavy smoke from the wildfire locations to periodically be transported into the DM/NFR area during this episode.
The combination of hot temperatures and extremely dry conditions set the stage for wildfires to increase significantly across the Pacific Northwest and northern Rockies in July and August of 2017. The persistent mid to upper level weather pattern with gusty surface winds allowed smoke production at the fires to continue, and provided a mechanism for long-range smoke transport from the Pacific Northwest and northern Rockies into the DM/NFR area.

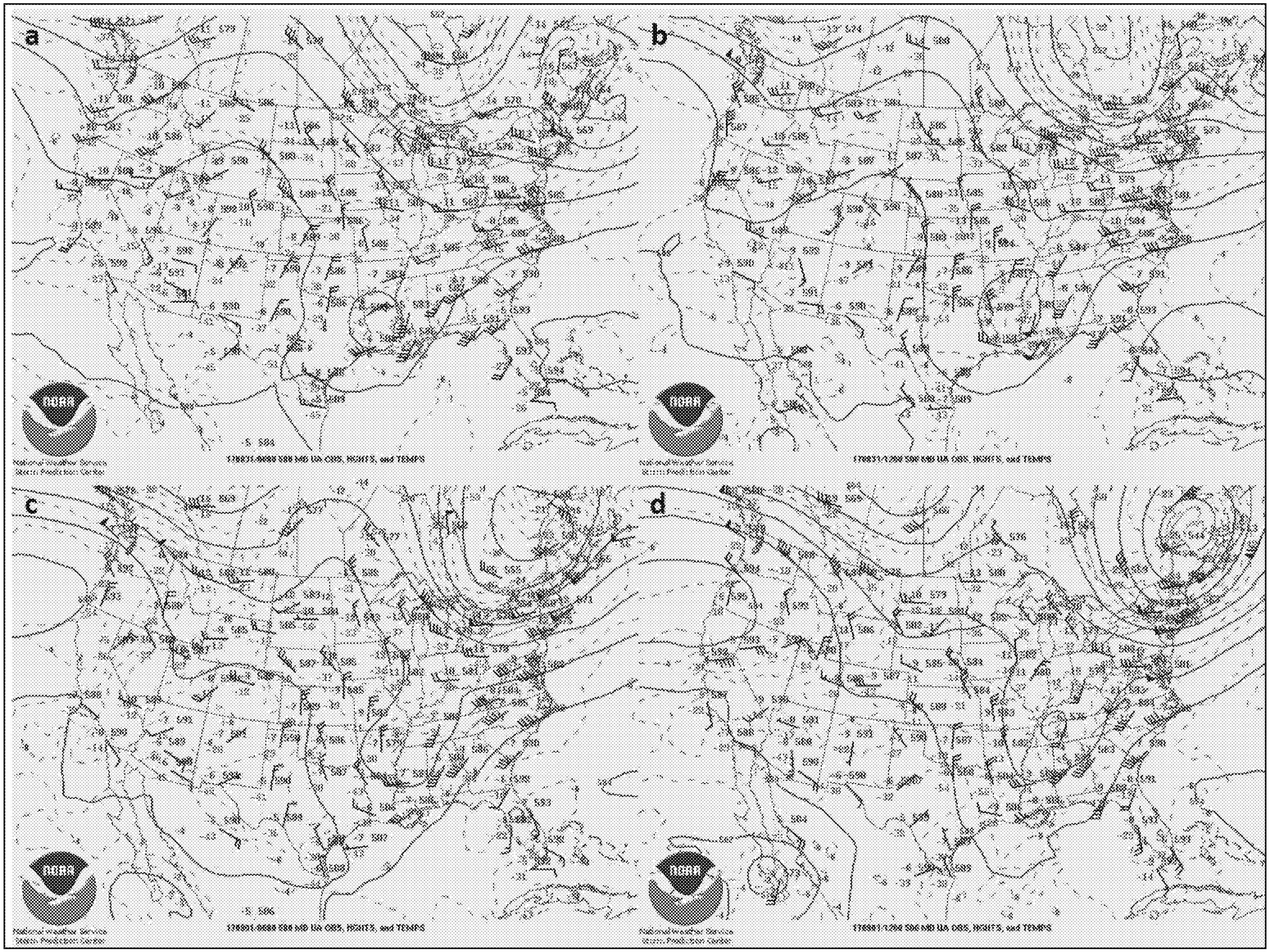


Figure 10a-d: NOAA 500 mb height and wind analysis at (a) 5:00 PM MST (0Z August 31, 2017) August 30, 2017; (b) 5:00 AM MST (12Z) August 31, 2017; (c) 5:00 PM MST (0Z September 1, 2017) August 31, 2017; and (d) 5:00 AM MST (12Z) September 1, 2017. (source: http://www.spc.noaa.gov/)

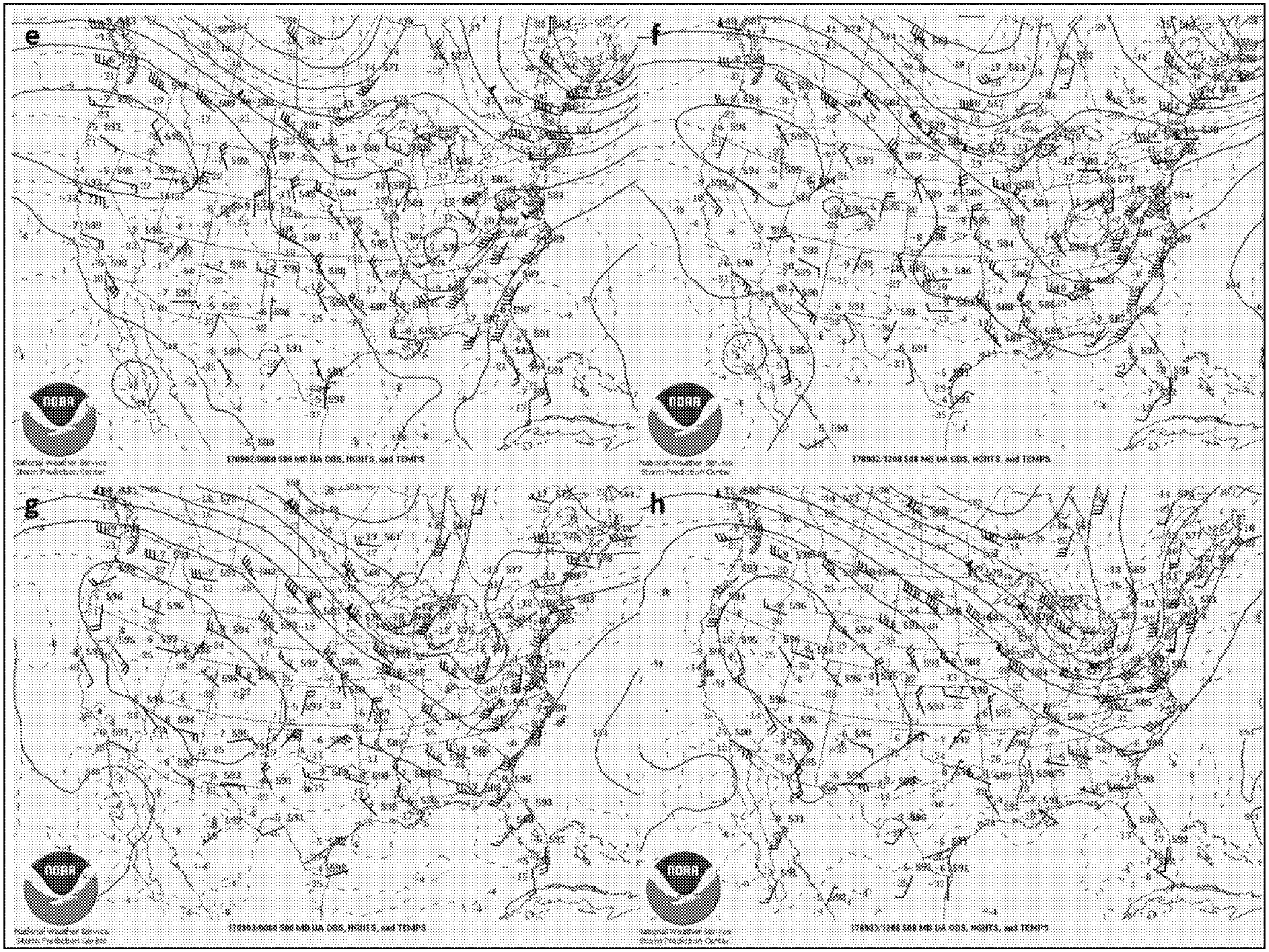


Figure 10e-h: NOAA 500 mb height and wind analysis at (e) 5:00 PM MST (0Z September 2, 2017) September 1, 2017; (f) 5:00 AM MST (12Z) September 2, 2017; (g) 5:00 PM MST (0Z September 3, 2017) September 2, 2017; and (d) 5:00 AM MST (12Z) September 3, 2017. (source: http://www.spc.noaa.gov/)

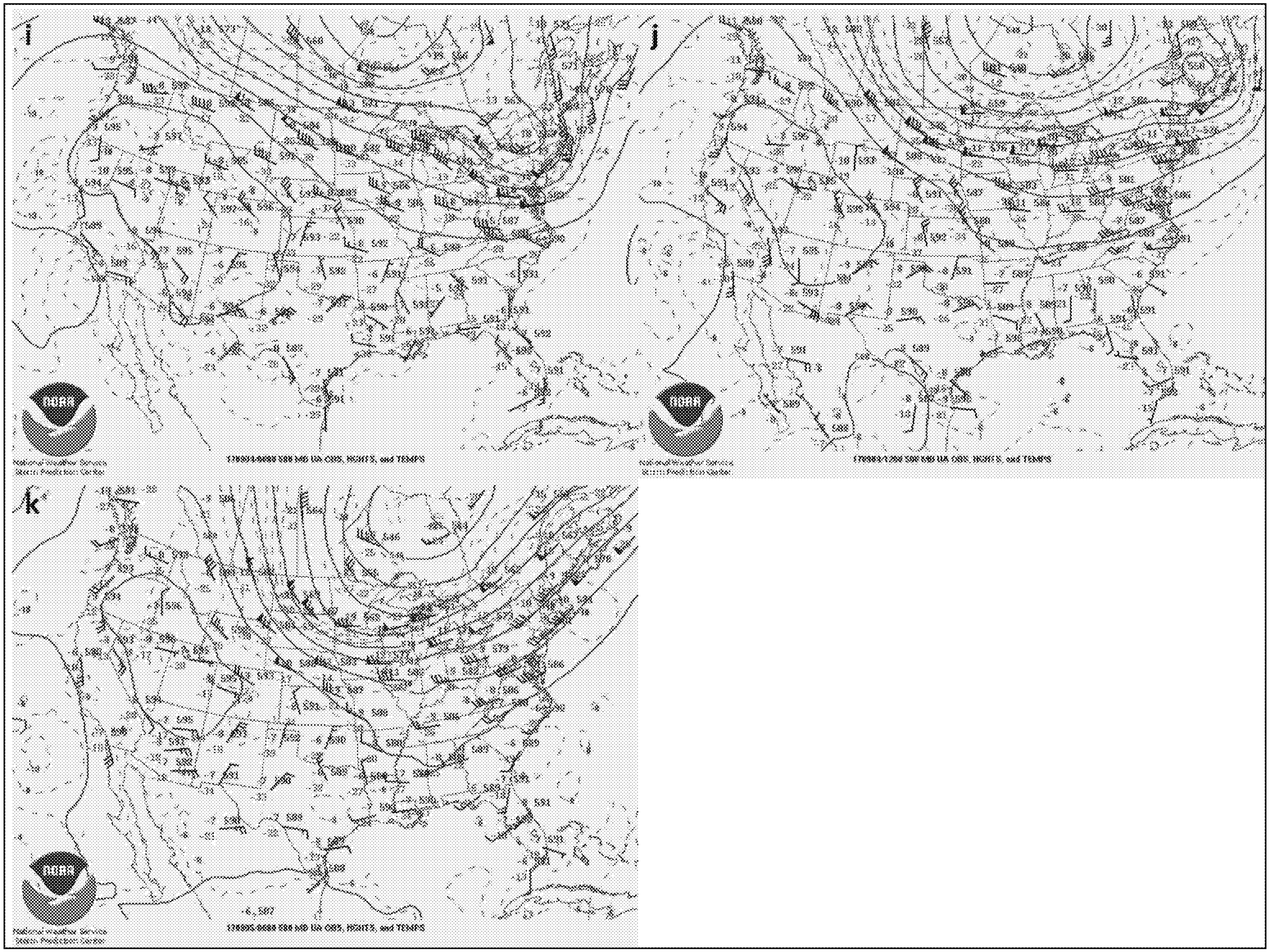


Figure 10i-k: NOAA 500 mb height and wind analysis at (i) 5:00 PM MST (0Z September 4, 2017) September 3, 2017; (j) 5:00 AM MST (12Z) September 4, 2017; (k) 5:00 PM MST (0Z September 5, 2017) September 4, 2017. (source: http://www.spc.noaa.gov/)

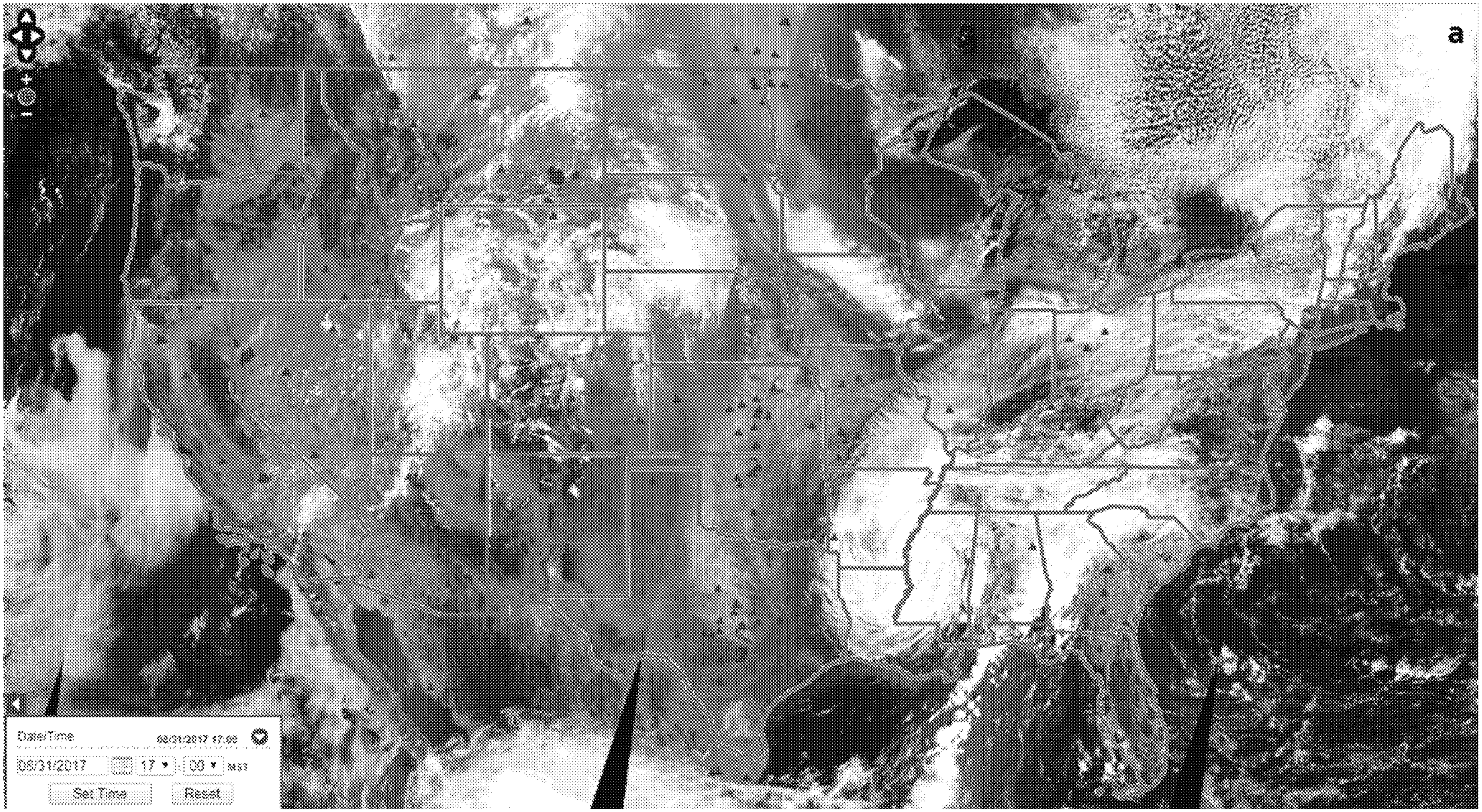


Figure 11a: MODIS Terra True Color satellite image with HMS Fire detection at 5:00 PM MST on August 31, 2017. (source: https://airnowtech.org/navigator)

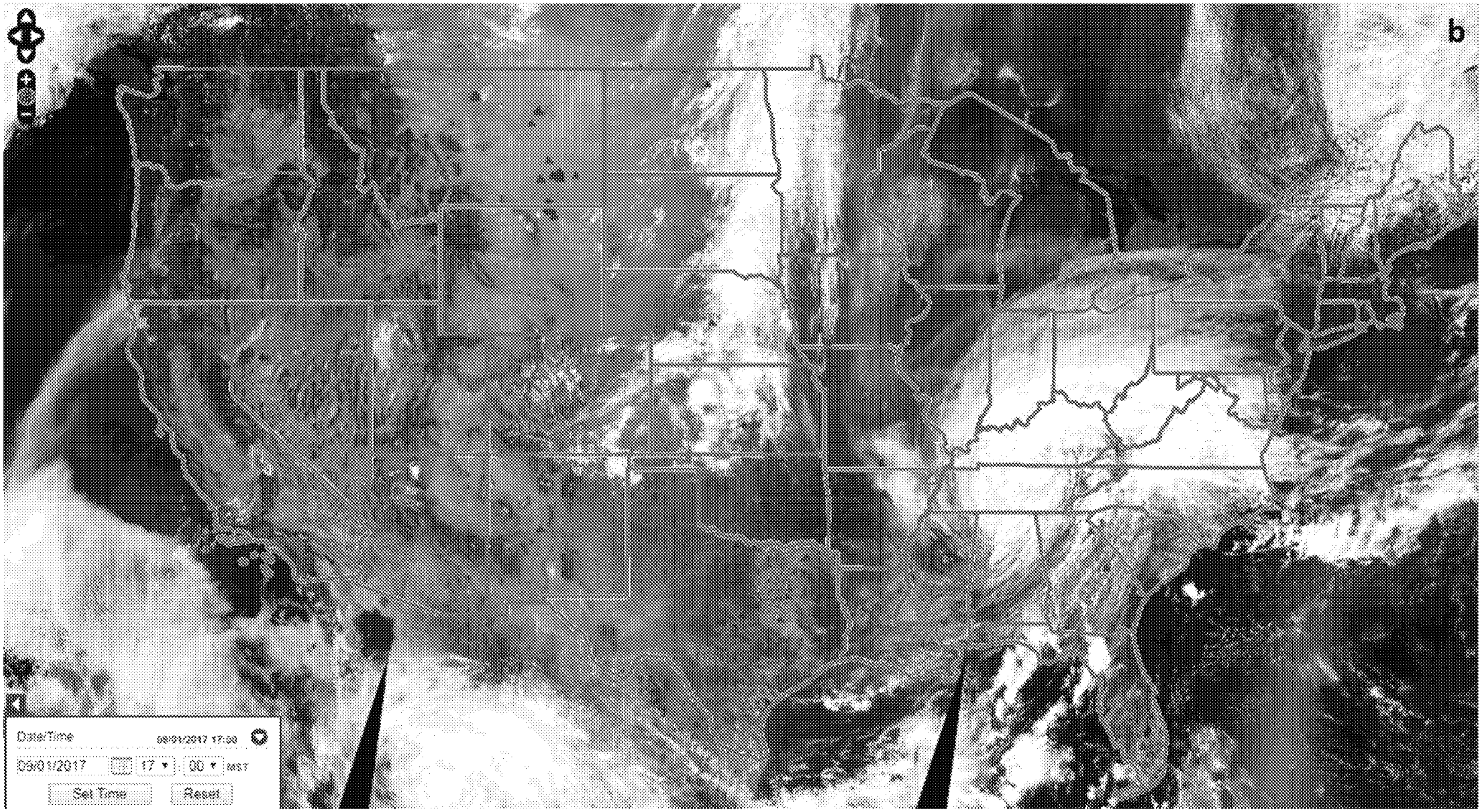


Figure 11b: MODIS Terra True Color satellite image with HMS Fire detection at 5:00 PM MST on September 1, 2017. (source: https://airnowtech.org/navigator)

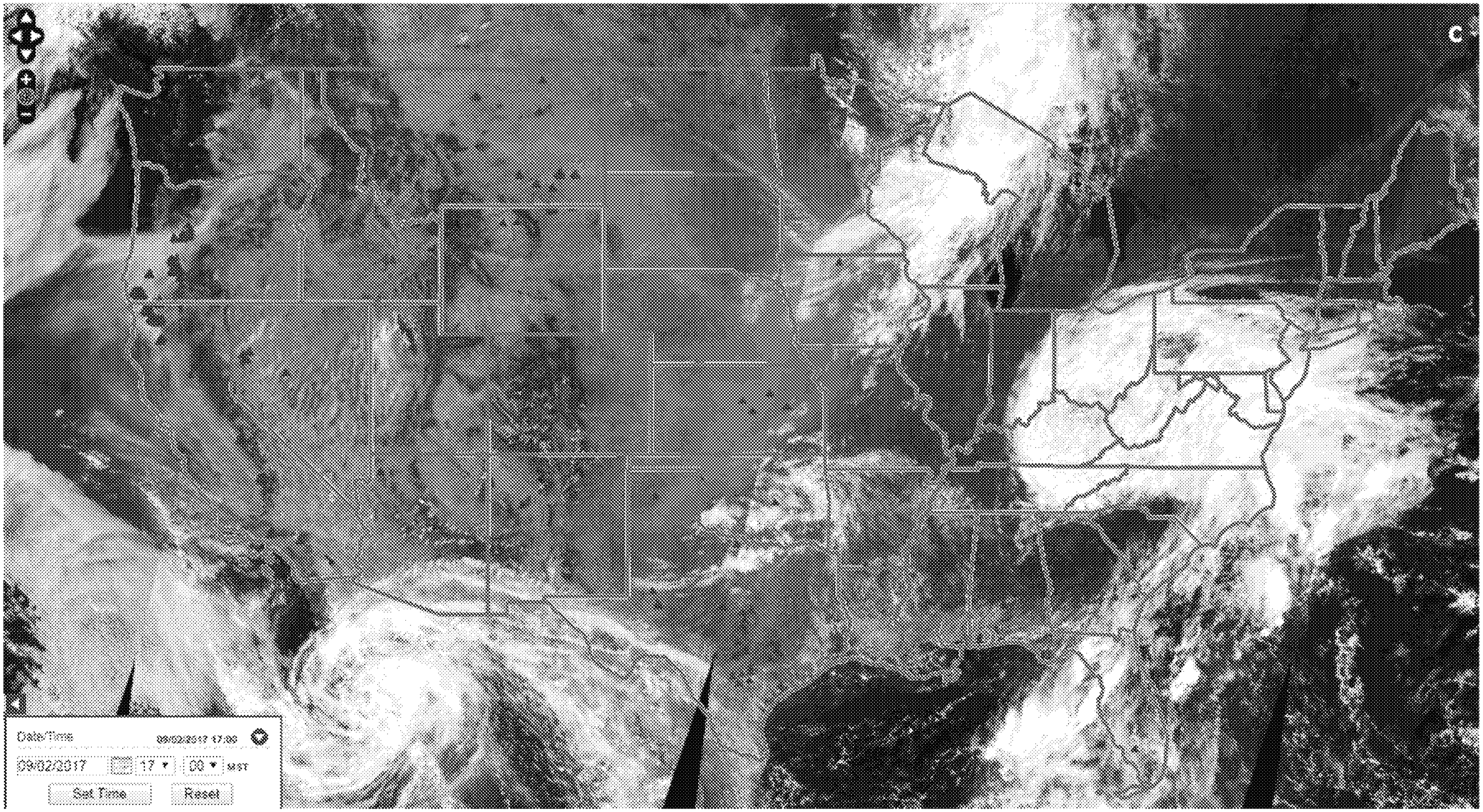


Figure 11c: MODIS Terra True Color satellite image with HMS Fire detection at 5:00 PM MST on September 2, 2017. (source: https://airnowtech.org/navigator)

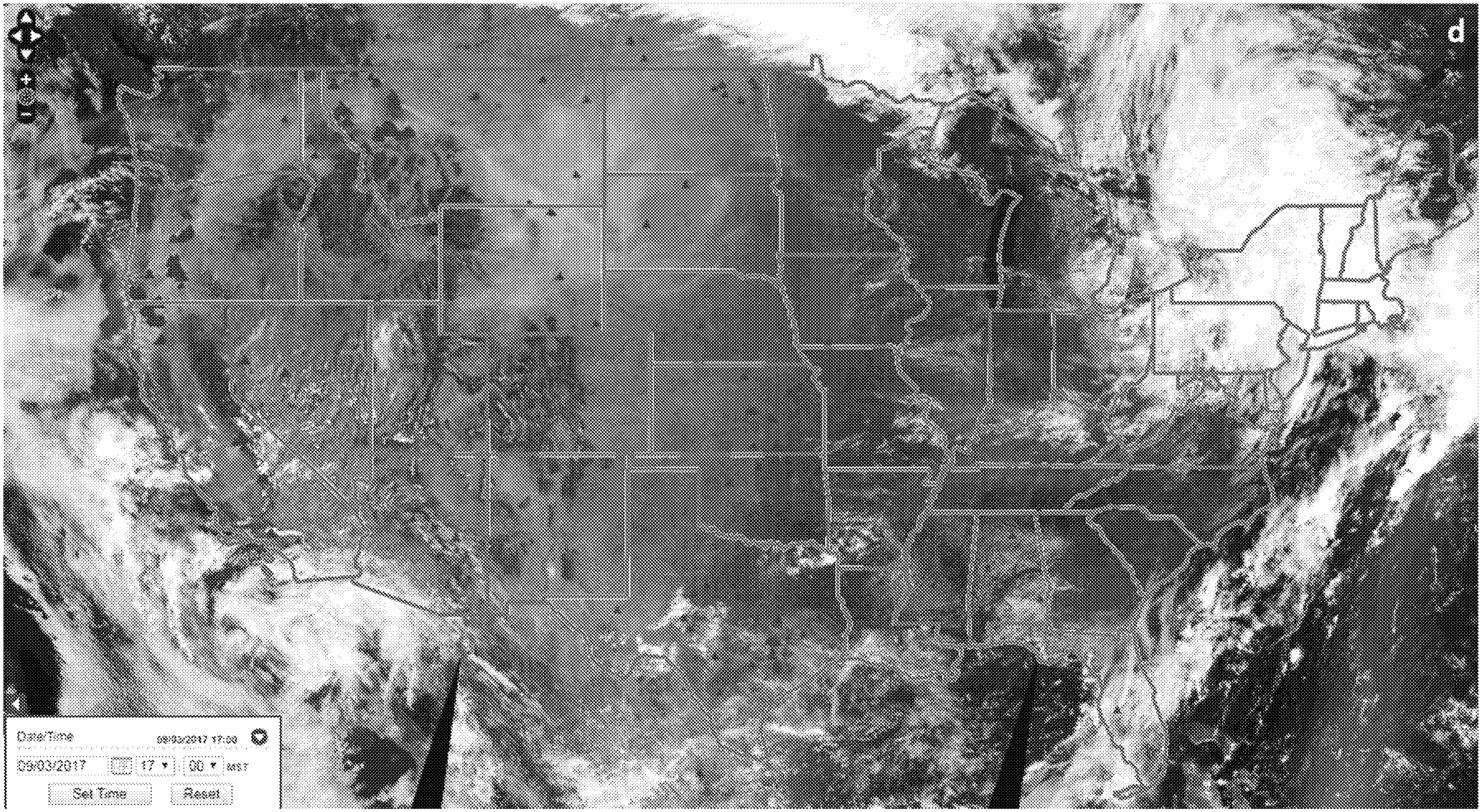


Figure 11d: MODIS Terra True Color satellite image with HMS Fire detection at 5:00 PM MST on September 3, 2017. (source: https://airnowtech.org/navigator)

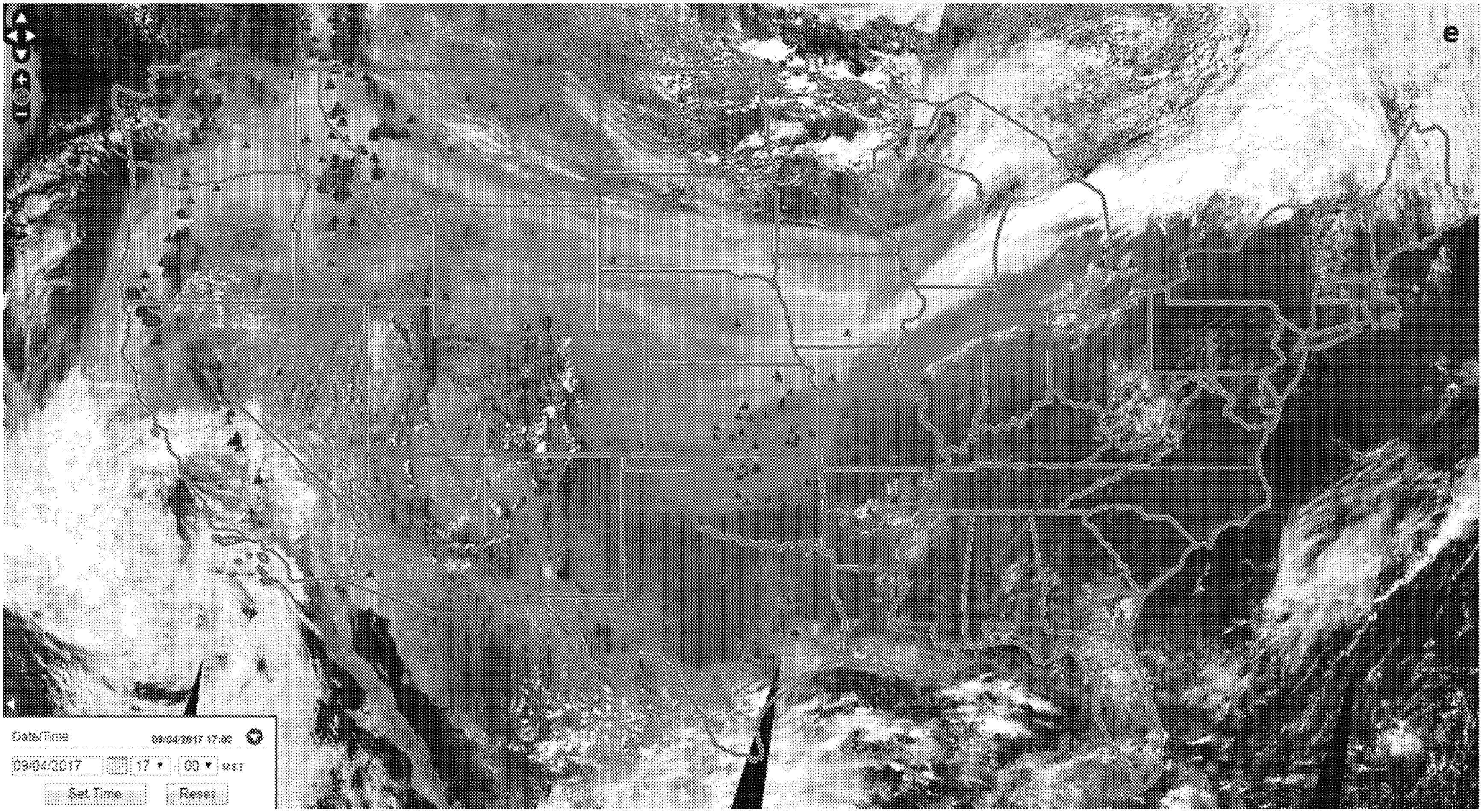


Figure 11e: MODIS Terra True Color satellite image with HMS Fire detection at 5:00 PM MST on September 4, 2017. (source: https://airnowtech.org/navigator)

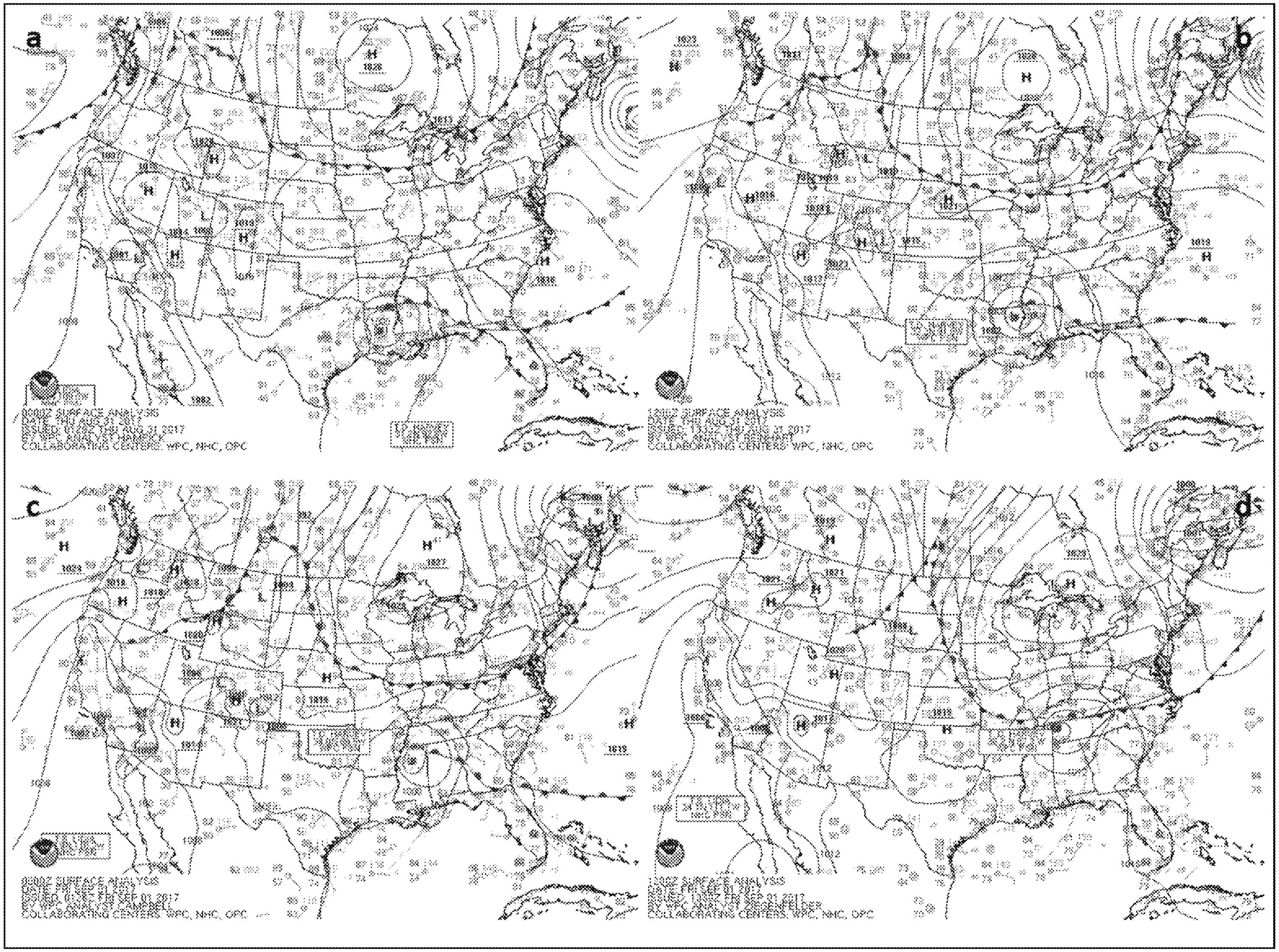


Figure 12a-d: NOAA surface analysis at (a) 5:00 PM MST (0Z August 31, 2017) August 30, 2017; (b) 5:00 AM MST (12Z) August 31, 2017; (c) 5:00 PM MST (0Z September 1, 2017) August 31, 2017; and (d) 5:00 AM MST (12Z) September 1, 2017. (source: http://www.wpc.ncep.noaa.gov/)

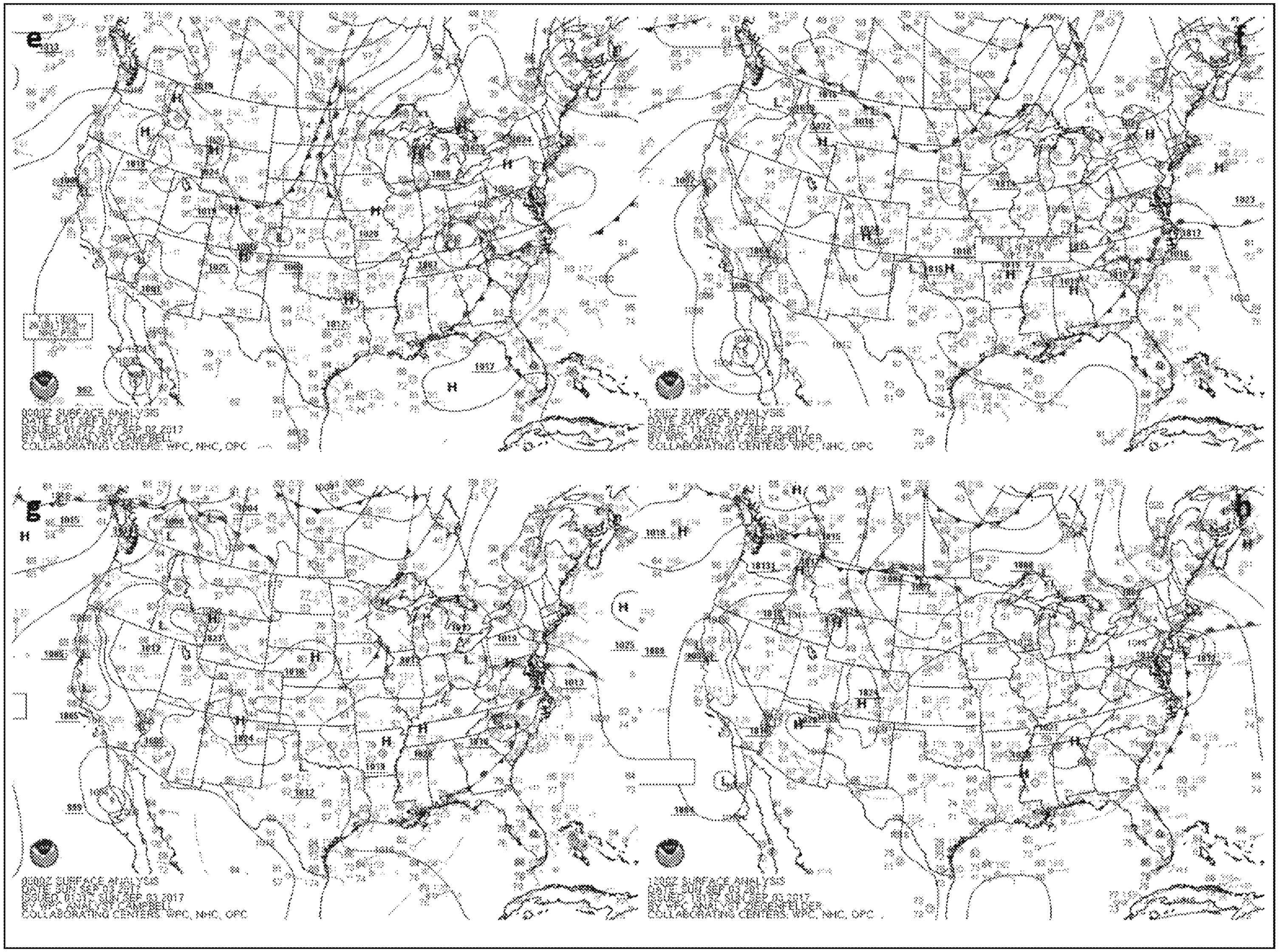


Figure 12e-h: NOAA surface analysis at (e) 5:00 PM MST (0Z September 2, 2017) September 1, 2017; (f) 5:00 AM MST (12Z) September 2, 2017; (g) 5:00 PM MST (0Z September 3, 2017) September 2, 2017; and (h) 5:00 AM MST (12Z) September 3, 2017. (source: http://www.wpc.ncep.noaa.gov/)

Figure 12i-k: NOAA surface analysis at (i) 5:00 PM MST (0Z September 4, 2017) September 3, 2017; (j) 5:00 AM MST (12Z) September 4, 2017; (k) 5:00 PM MST (0Z September 5, 2017) September 4, 2017. (source: http://www.wpc.ncep.noaa.gov/)

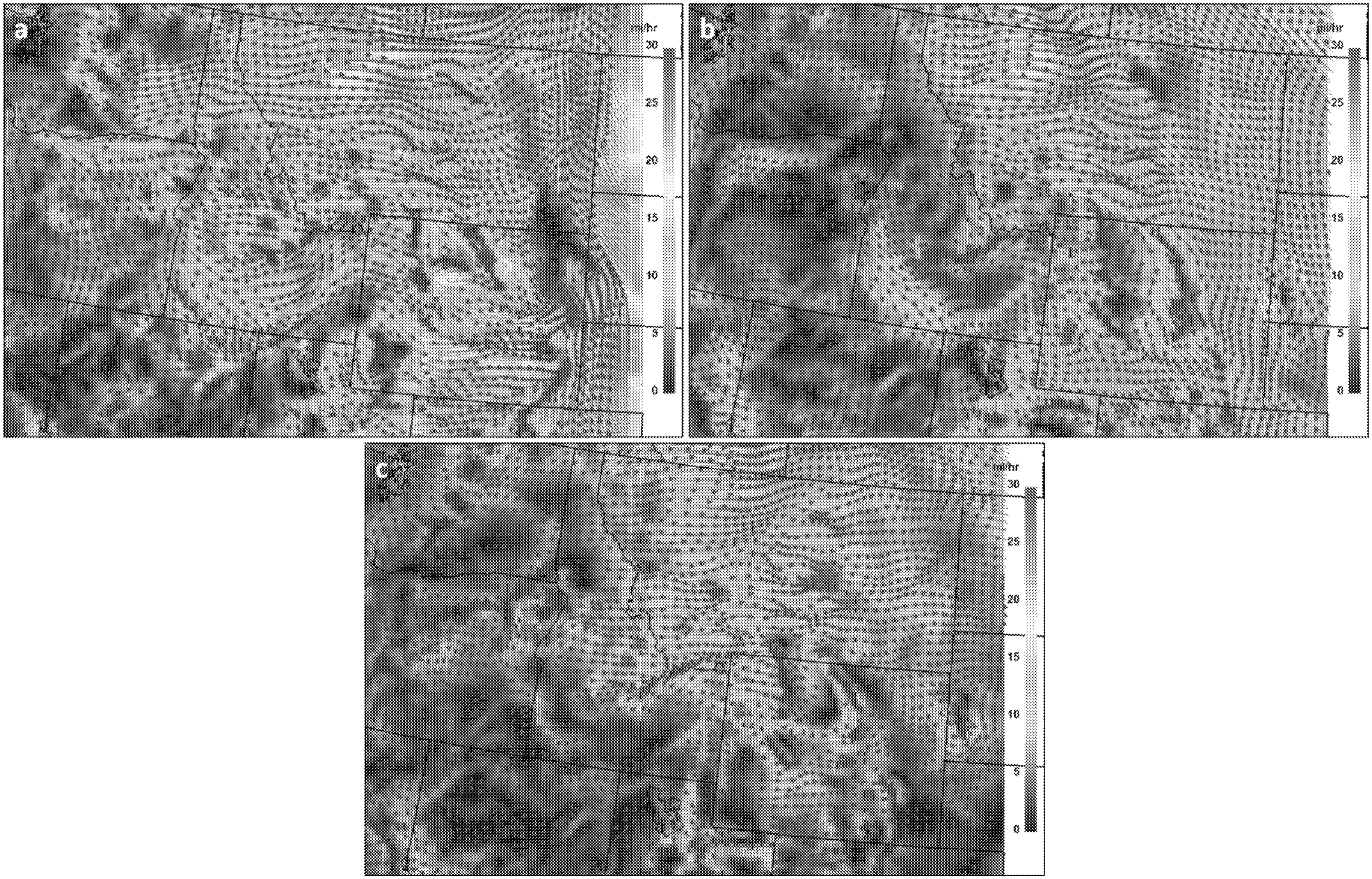
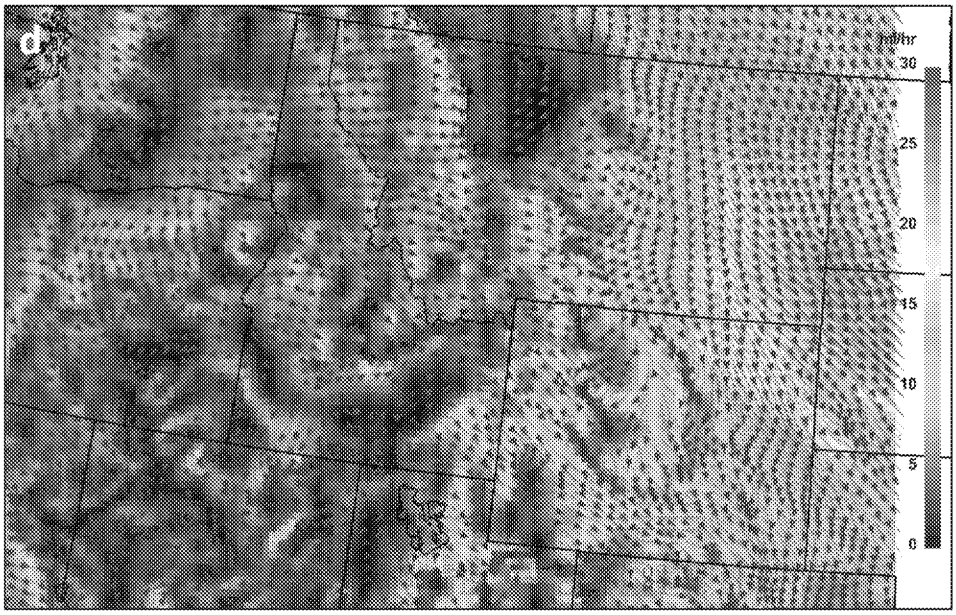


Figure 13a-c: NAM analysis surface wind vectors and speed for (a) 2:00 PM MST (21Z) August 31, 2017, (b) 2:00 PM MST (21Z) September 1, 2017, (c) 2:00 PM MST (21Z) September 2, 2017. (source: https://nomads.ncdc.noaa.gov/thredds/catalog.html).



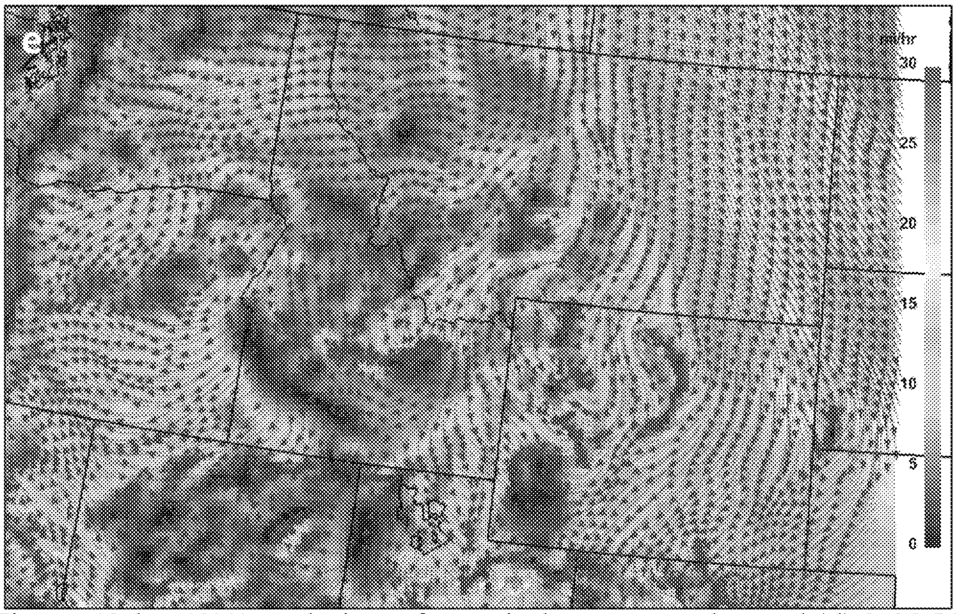


Figure 13d-e: NAM analysis surface wind vectors and speed (d) 2:00 PM MST (21Z) September 3, 2017, and (e) 2:00 PM MST (21Z) September 4, 2017. (source: https://nomads.ncdc.noaa.gov/thredds/catalog.html).

3.3.3 Summary of Wildfire Conditions during Episode

The conditions during the summer months of 2017 described in Section 3.3.1 resulted in above normal, significant wildland fire potential across the northwestern U.S. for August and September 2017 (Figure 14 and 15). This fire potential manifested due to the surface and upper level weather during this episode. As fire weather and fire danger increased, fires grew in size and reports of smoke and new fires increased throughout the week surrounding this exceptional event. Hazard Mapping System (HMS) Smoke and Fire detection for August 31 through September 4, 2017 are presented in Figure 16a-e. From this evidence, it is clear fires were numerous and resultant smoke widespread during this time period. Figure 17a-e shows 8-hr maximum O_3 concentrations and Figure 18a-e displays 24-hr average $PM_{2.5}$ concentrations for each day during this window, illustrating extreme concentrations of $PM_{2.5}$ in smoke plumes and elevated O_3 in regions with dispersed/aged smoke.

During the 7-day window from August 30-September 5, 2017, 926,198 acres burned in the quadrant of the U.S. to the west and north of the DM/NFR area, with several mega fires crossing the threshold of over 100,000 acres.

Figure 14: Significant Wildland Fire Potential Outlook for August 2017. (source: https://www.predictiveservices.nifc.gov)

Figure 15: Significant Wildland Fire Potential Outlook for September 2017. (source: https://www.predictiveservices.nifc.gov)

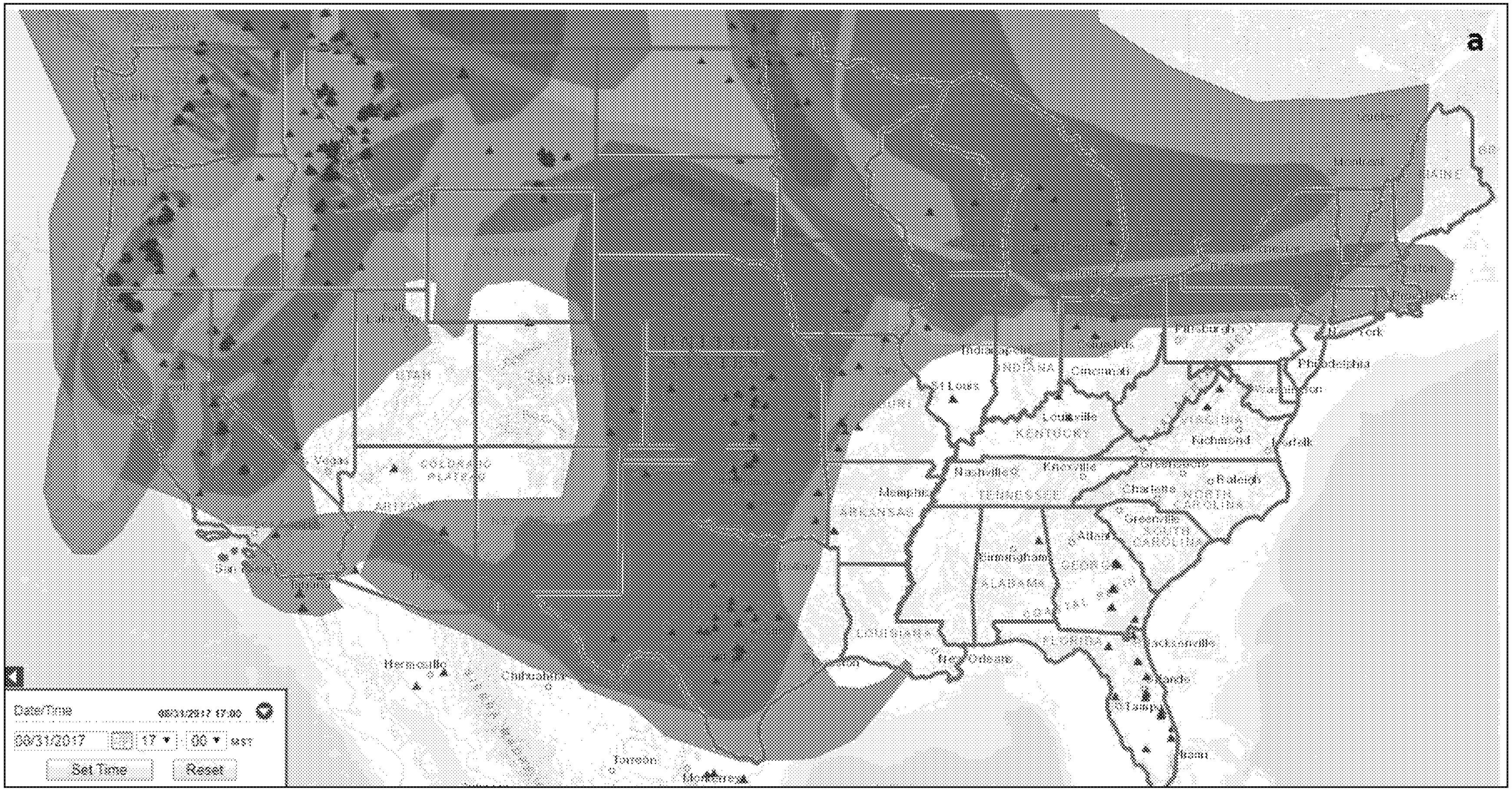


Figure 16a: HMS Fire and Smoke detection at 5:00 PM MST on August 31, 2017. (source: https://airnowtech.org/navigator)

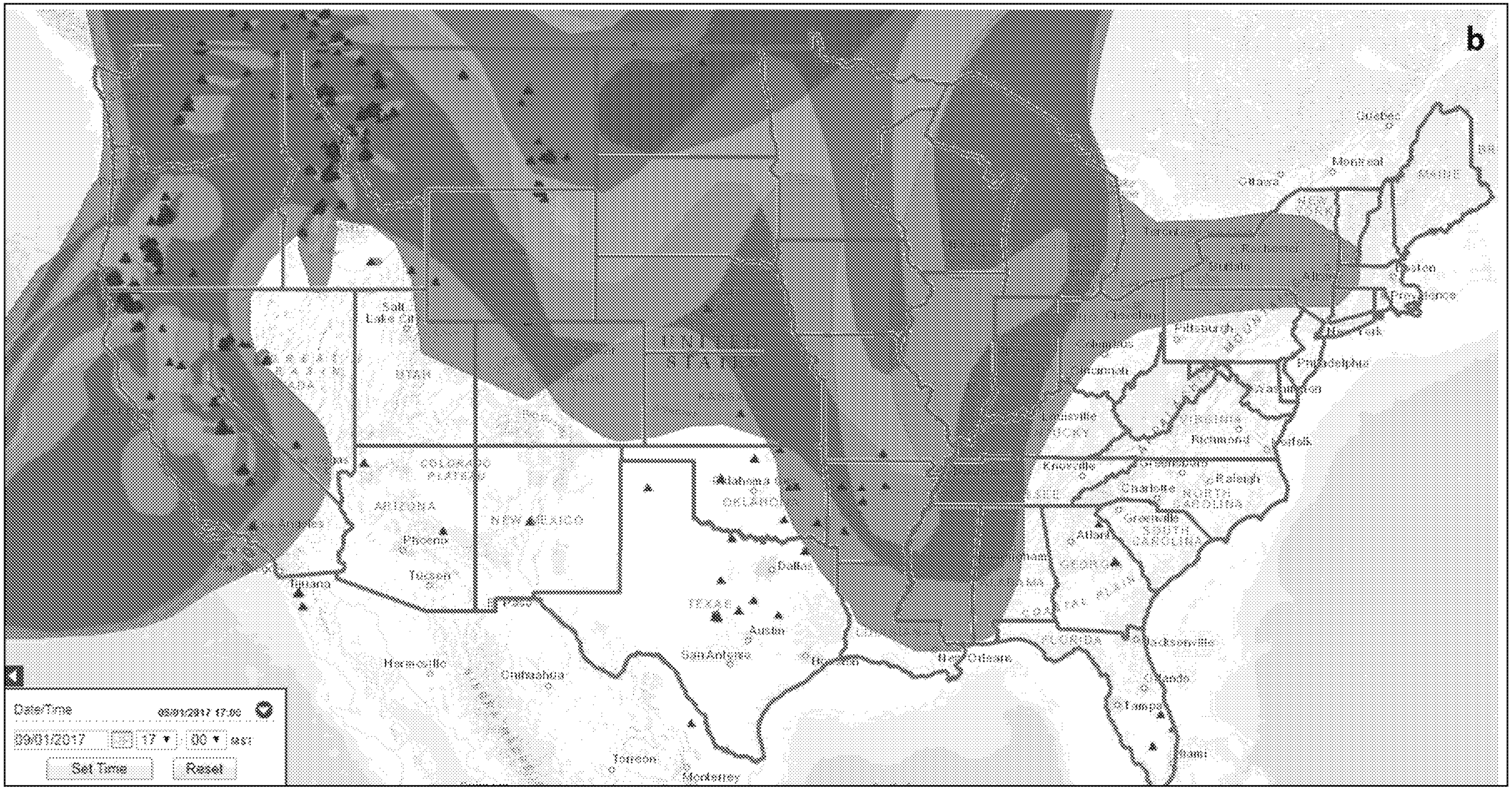


Figure 16b: HMS Fire and Smoke detection at 5:00 PM MST on September 1, 2017. (source: https://airnowtech.org/navigator)

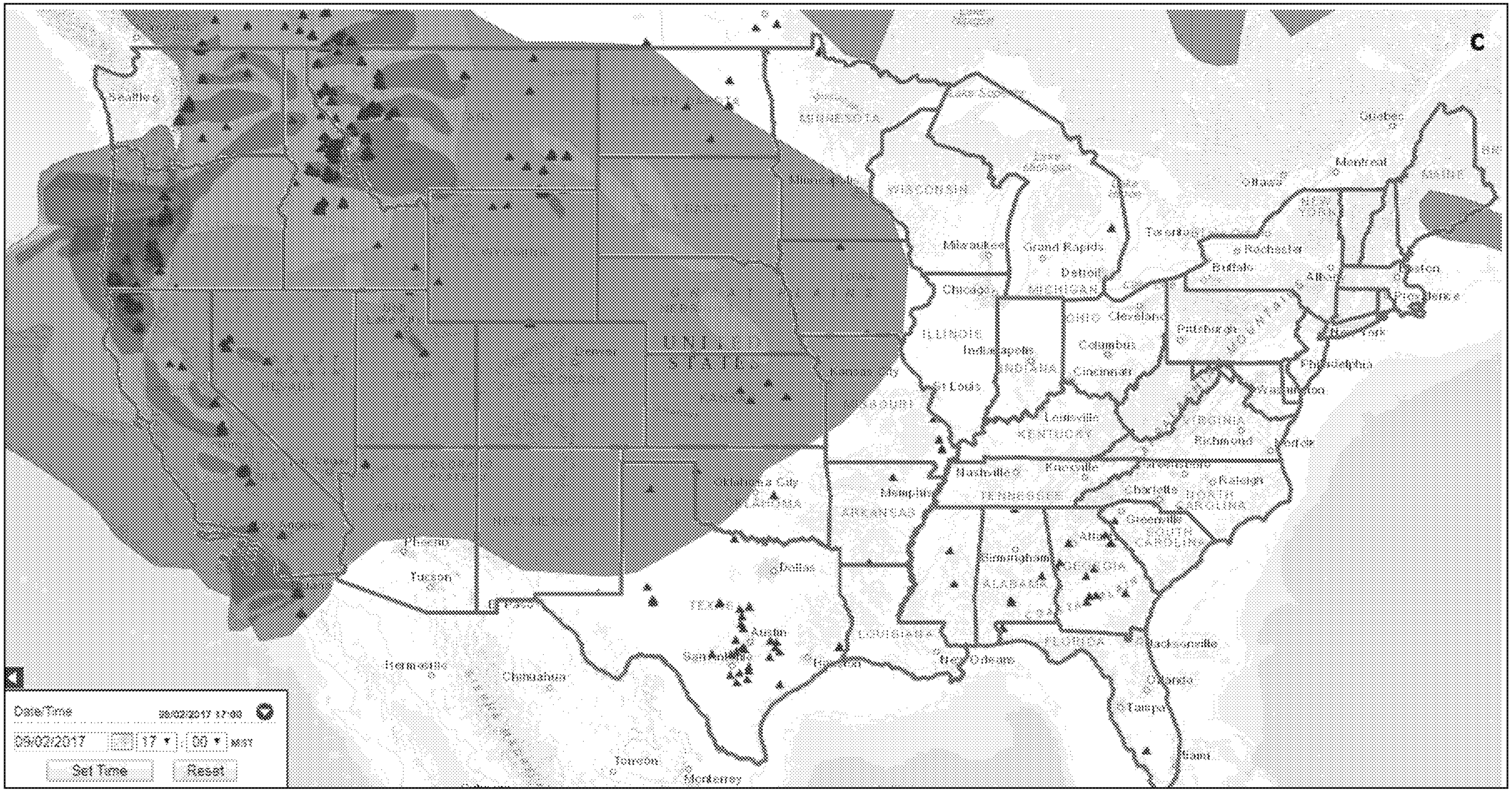


Figure 16c: HMS Fire and Smoke detection at 5:00 PM MST on September 2, 2017. (source: https://airnowtech.org/navigator)

ED_002666_00018495-00051

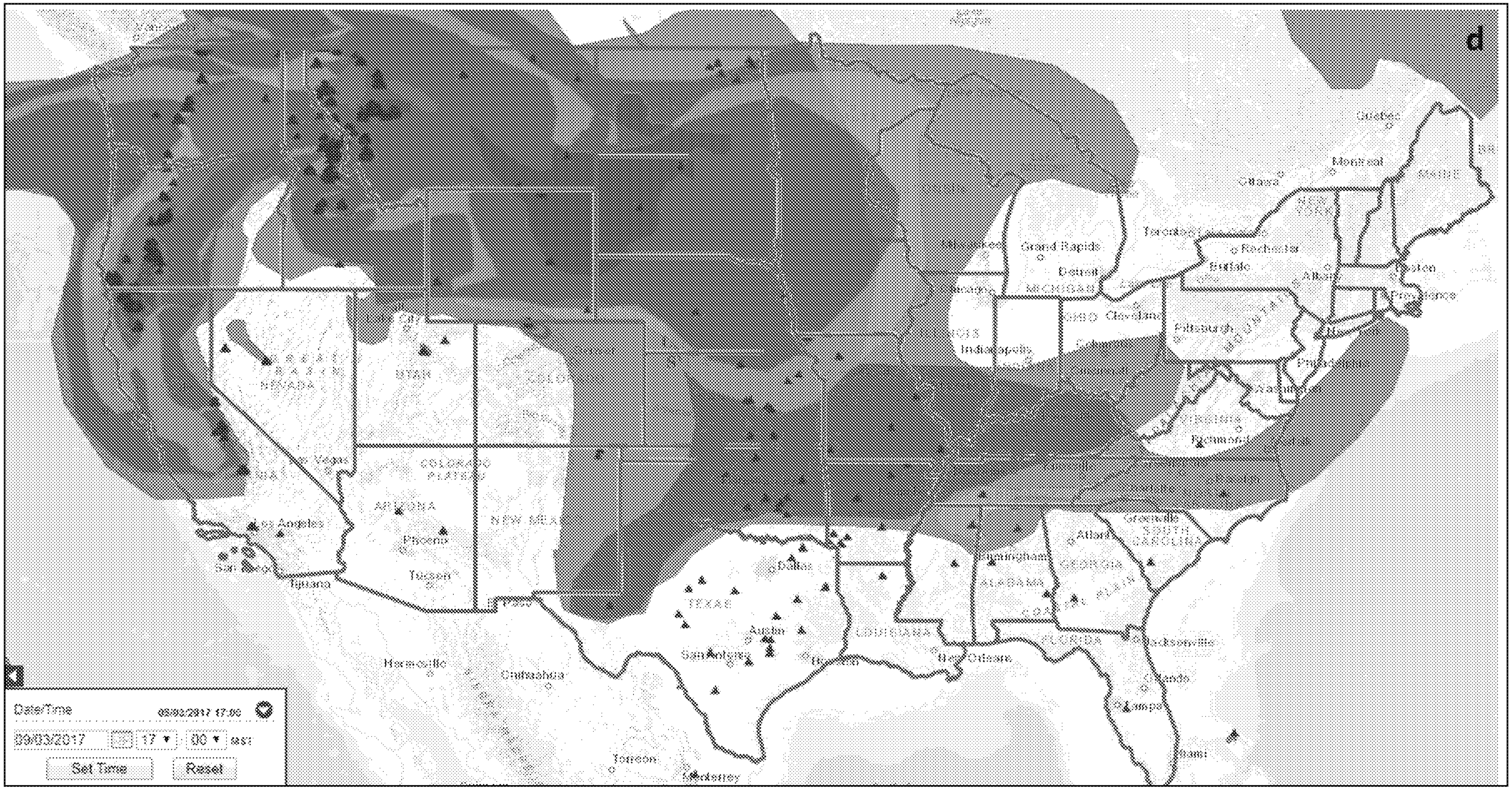


Figure 16d: HMS Fire and Smoke detection at 5:00 PM MST on September 3, 2017. (source: https://airnowtech.org/navigator)

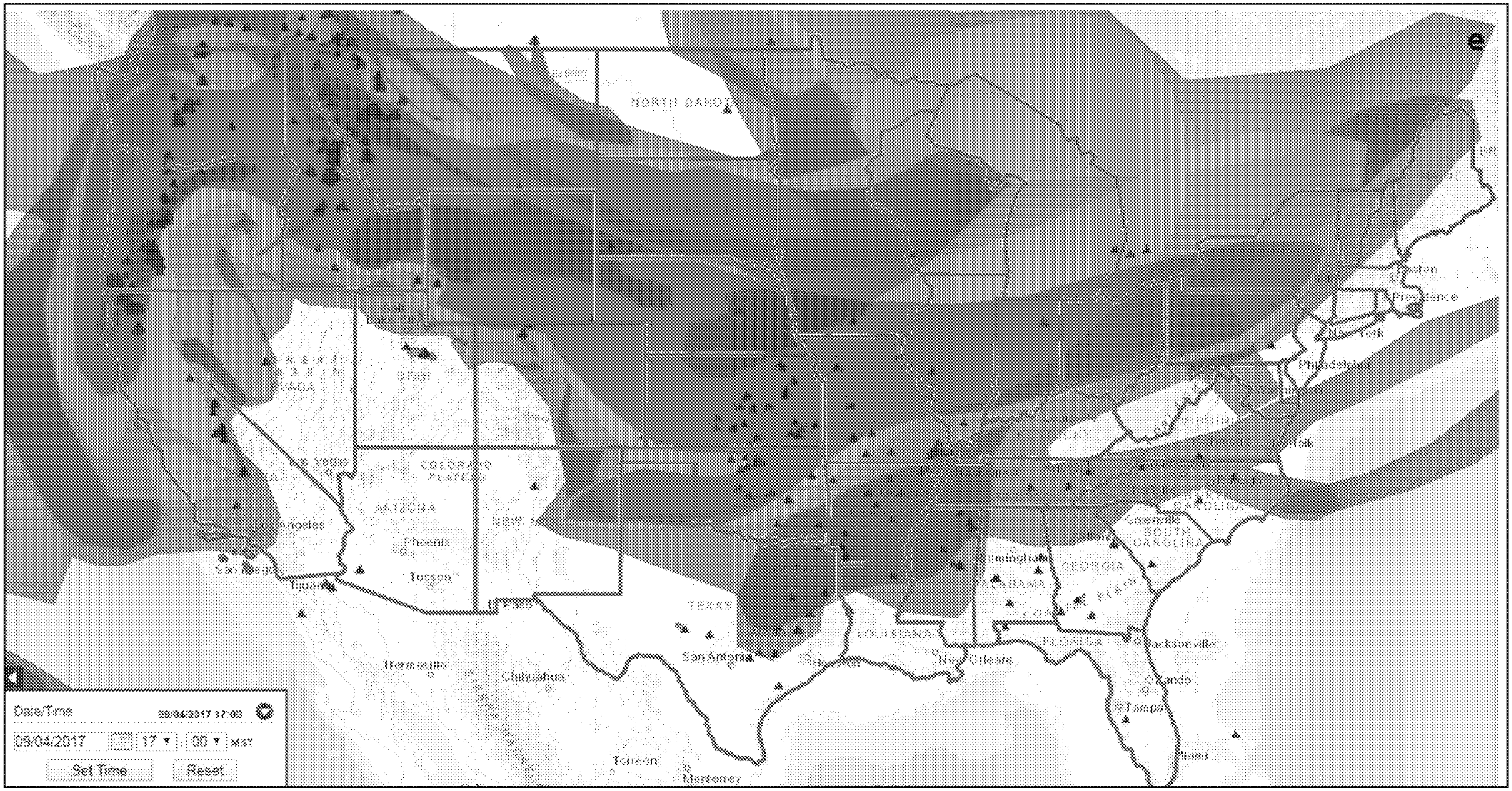


Figure 16e: HMS Fire and Smoke detection at 5:00 PM MST on September 4, 2017. (source: https://airnowtech.org/navigator)

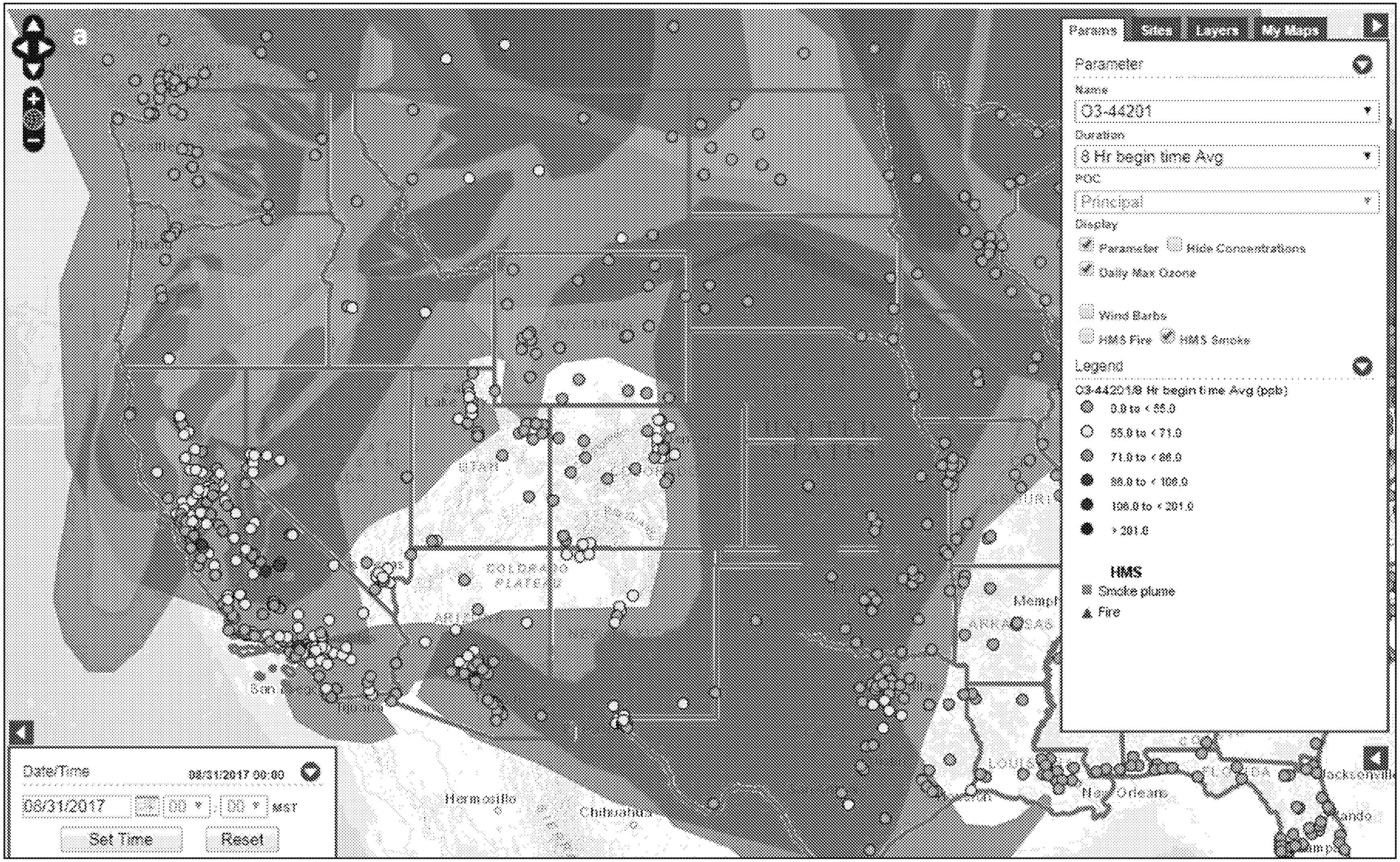


Figure 17a: HMS Smoke detection and 8-hr O_3 maximum concentration on August 31, 2017. (source: https://airnowtech.org/navigator)

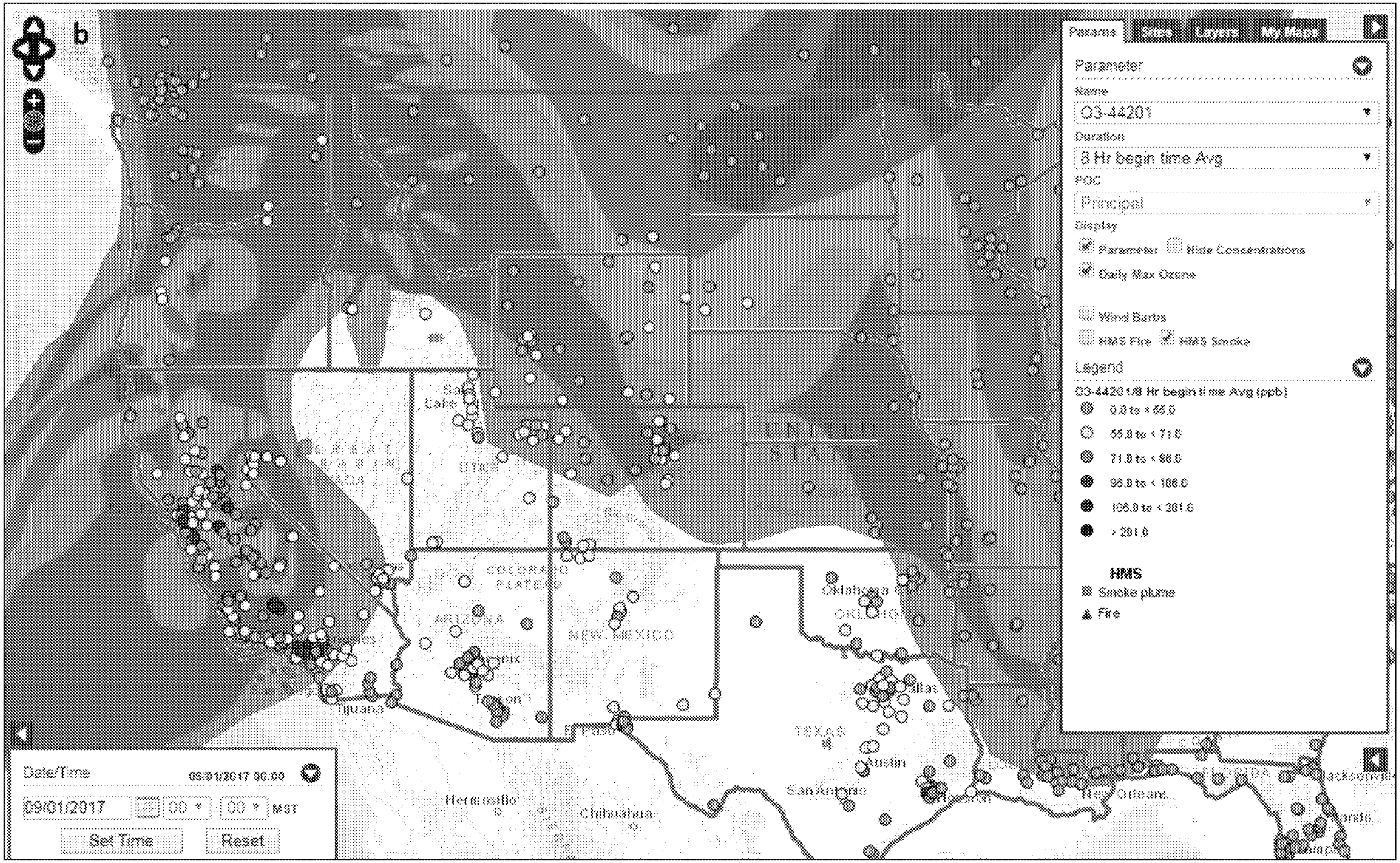


Figure 17b: HMS Smoke detection and 8-hr O_3 maximum concentration on September 1, 2017. (source: https://airnowtech.org/navigator)

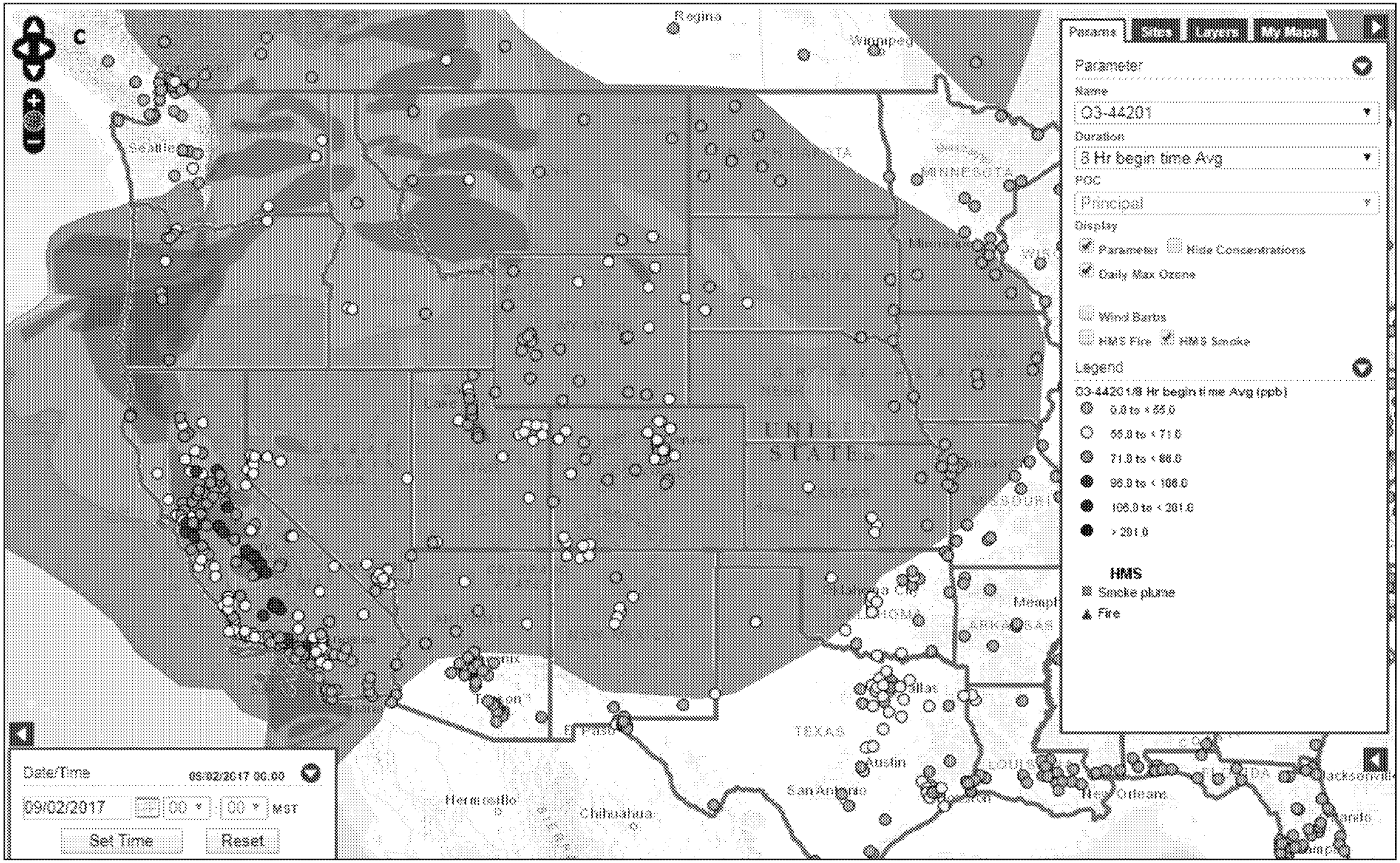


Figure 17c: HMS Smoke detection and 8-hr O_3 maximum concentration on September 2, 2017. (source: https://airnowtech.org/navigator)

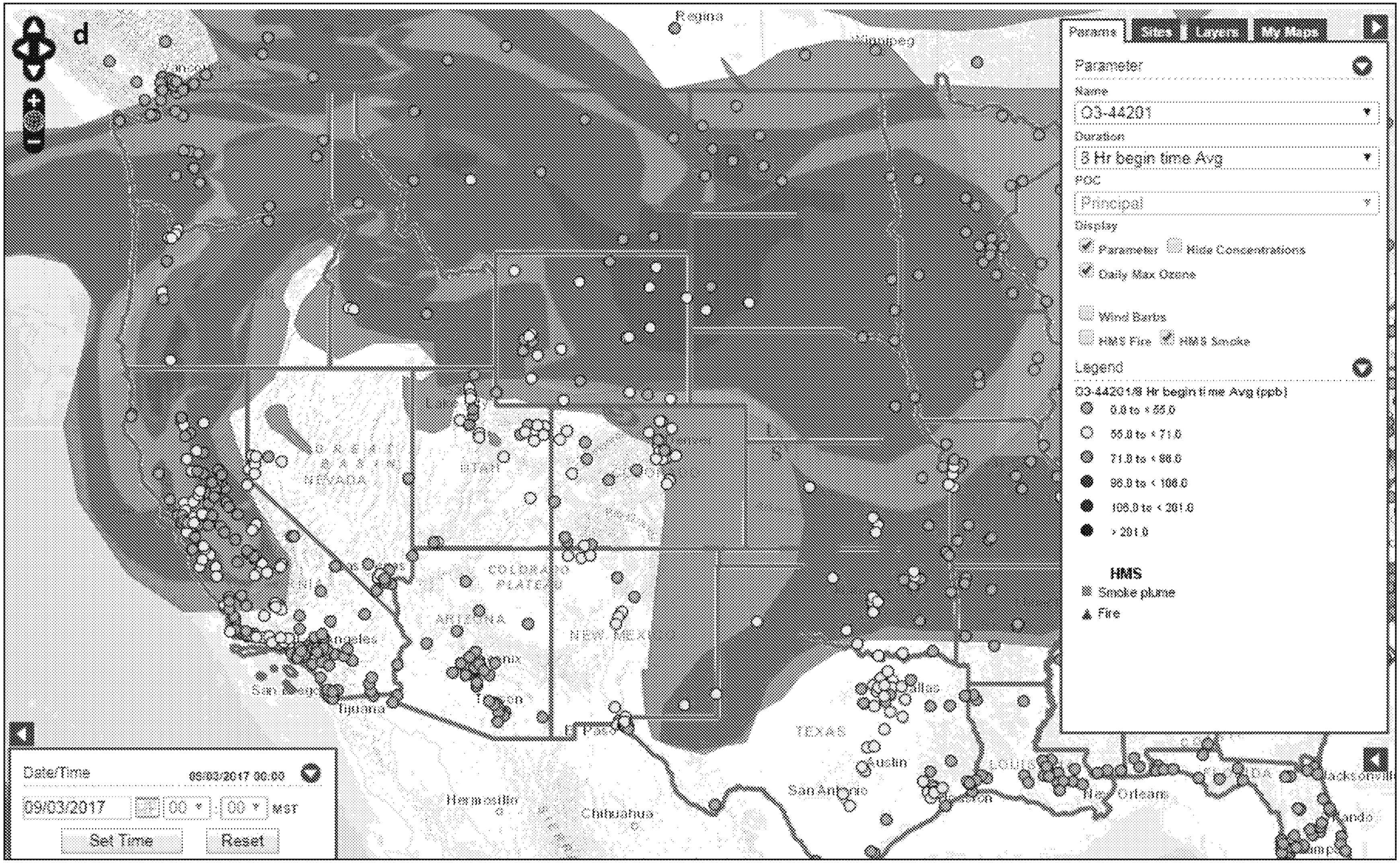


Figure 17d: HMS Smoke detection and 8-hr O_3 maximum concentration on September 3, 2017. (source: https://airnowtech.org/navigator)

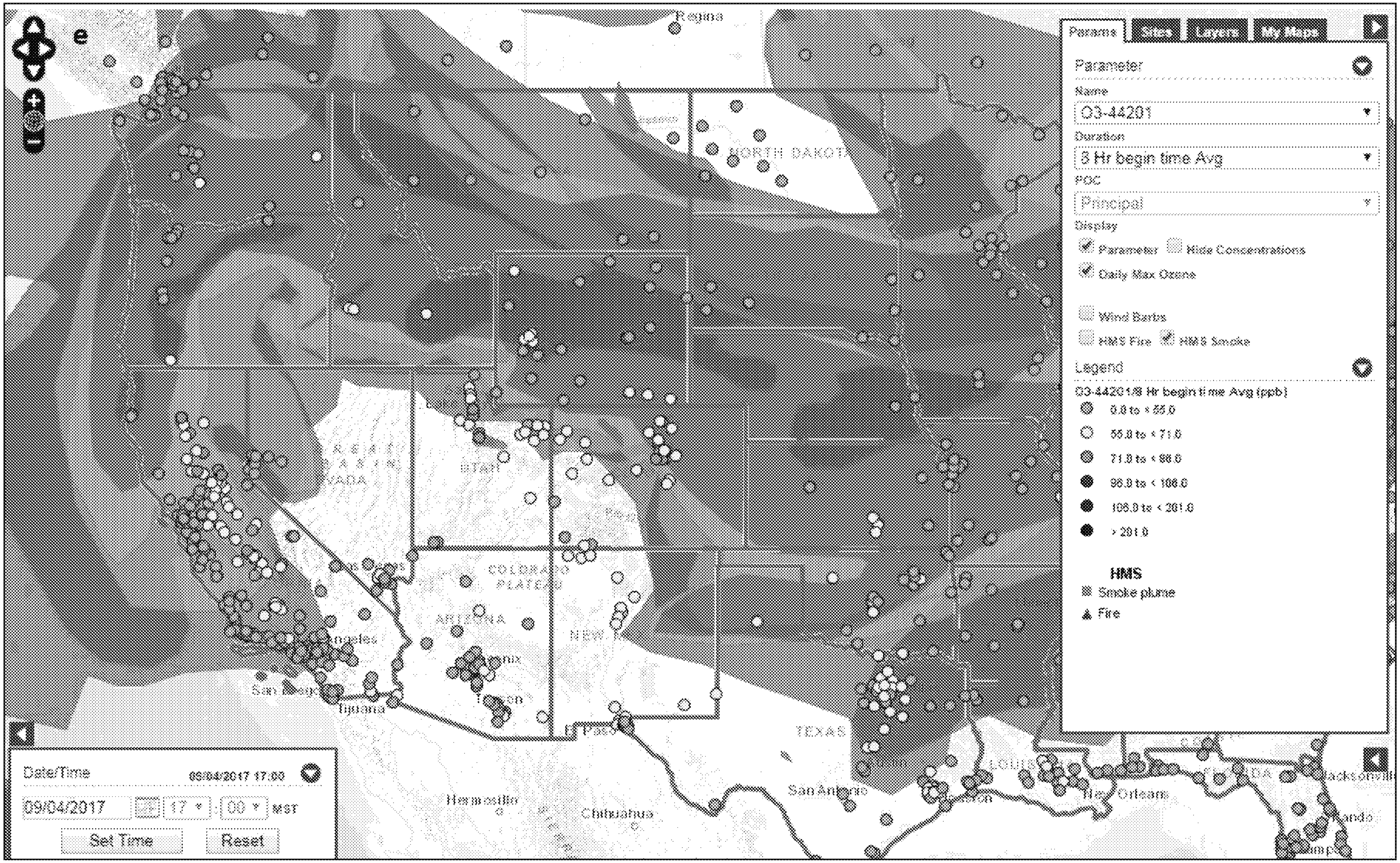


Figure 17e: HMS Smoke detection and 8-hr O_3 maximum concentration on September 4, 2017. (source: https://airnowtech.org/navigator)

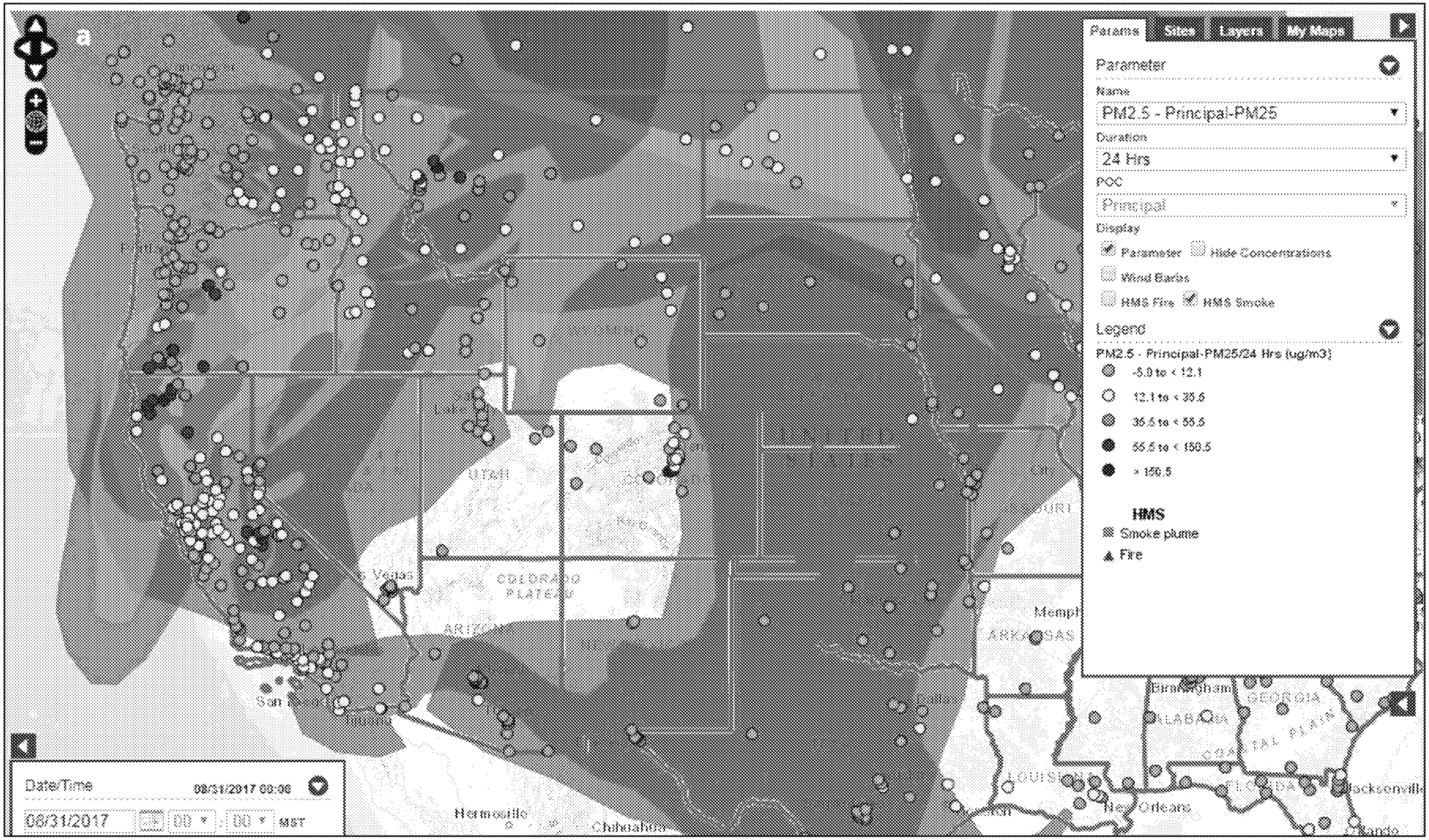


Figure 18a: HMS Smoke detection and 24-hr average $PM_{2.5}$ concentration on August 31, 2017. (source: https://airnowtech.org/navigator)

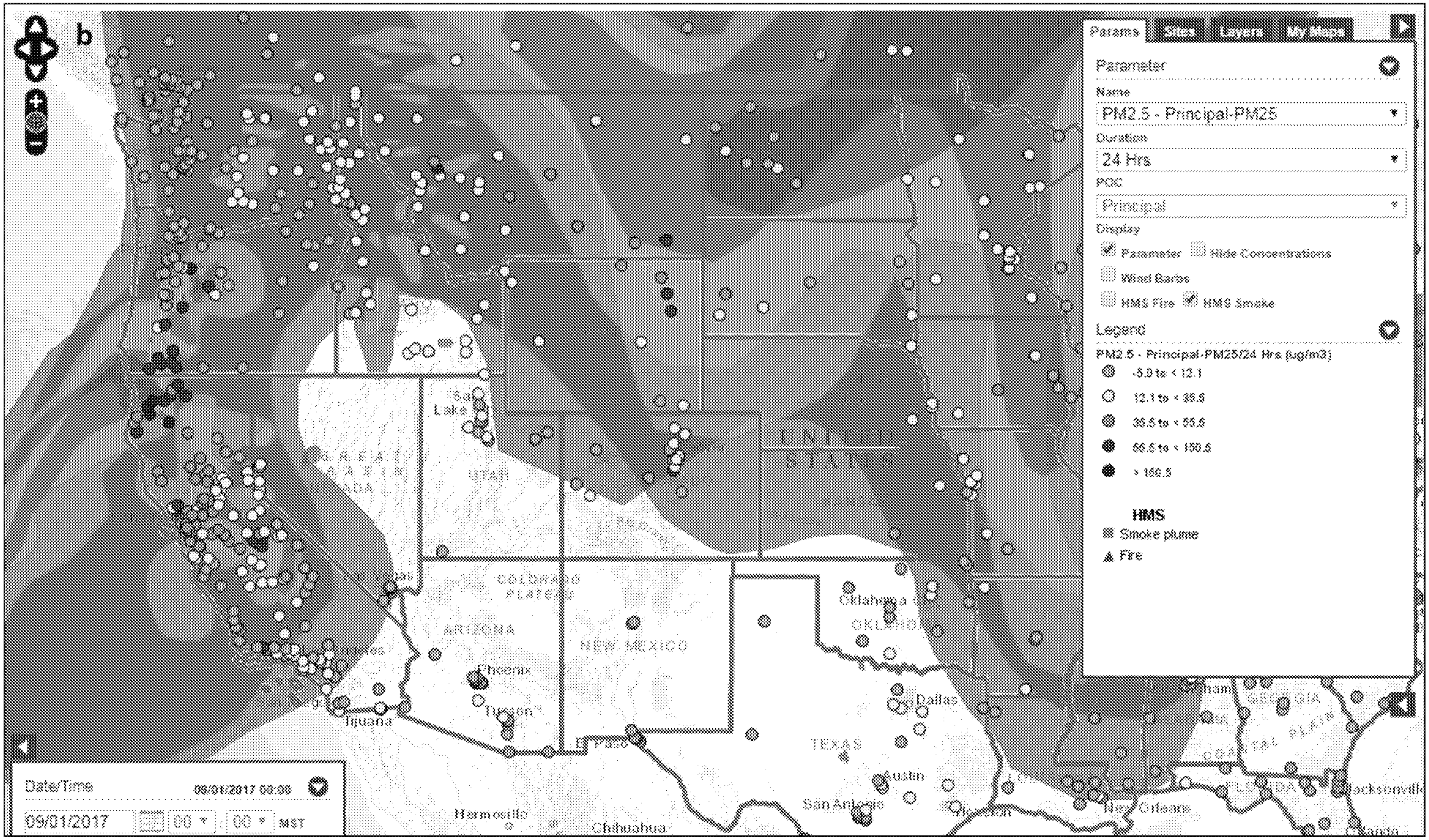


Figure 18b: HMS Smoke detection and 24-hr average $PM_{2.5}$ concentration on September 1, 2017. (source: https://airnowtech.org/navigator)

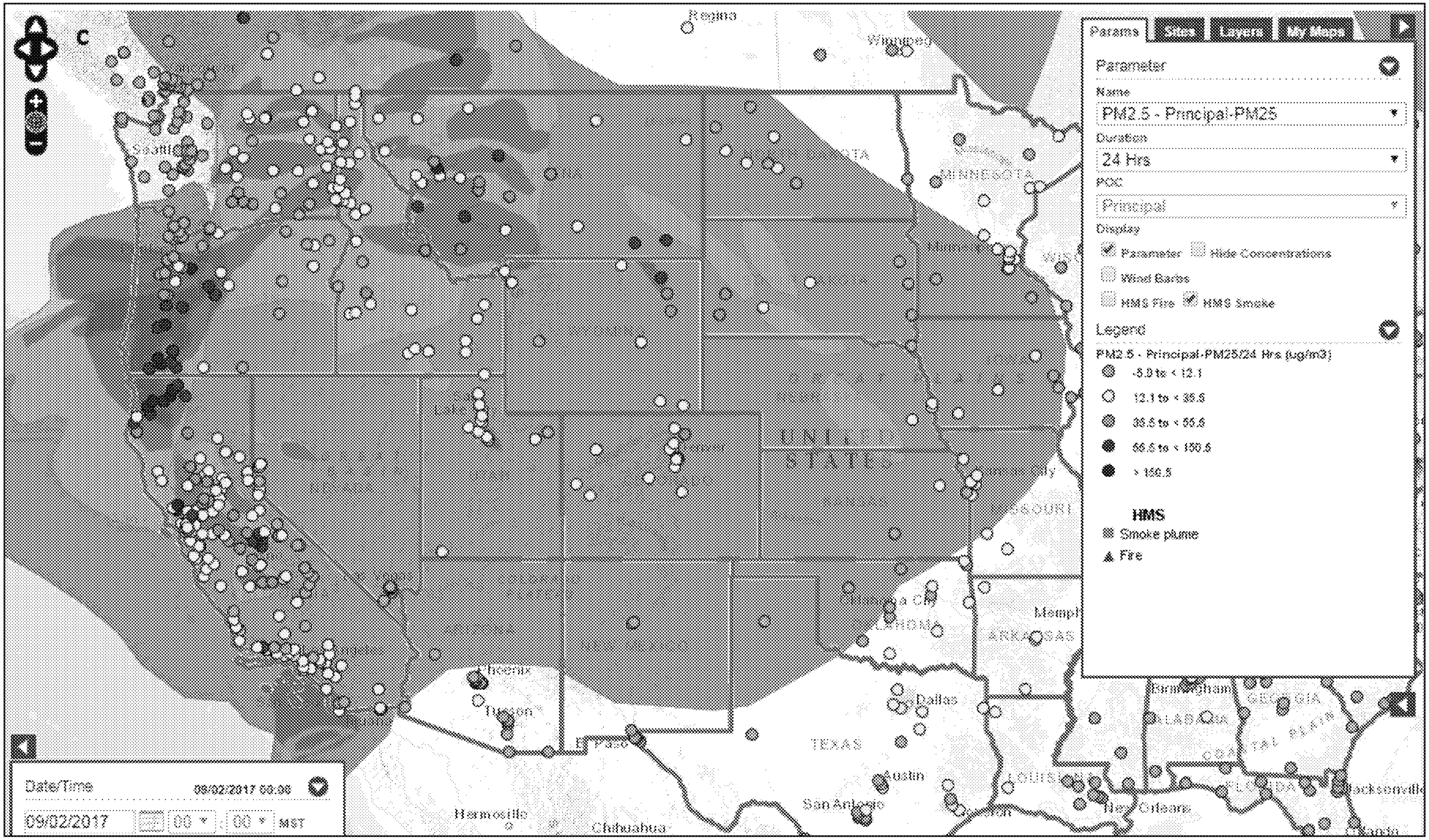


Figure 18c: HMS Smoke detection and 24-hr average PM$_{2.5}$ concentration on September 2, 2017. (source: https://airnowtech.org/navigator)

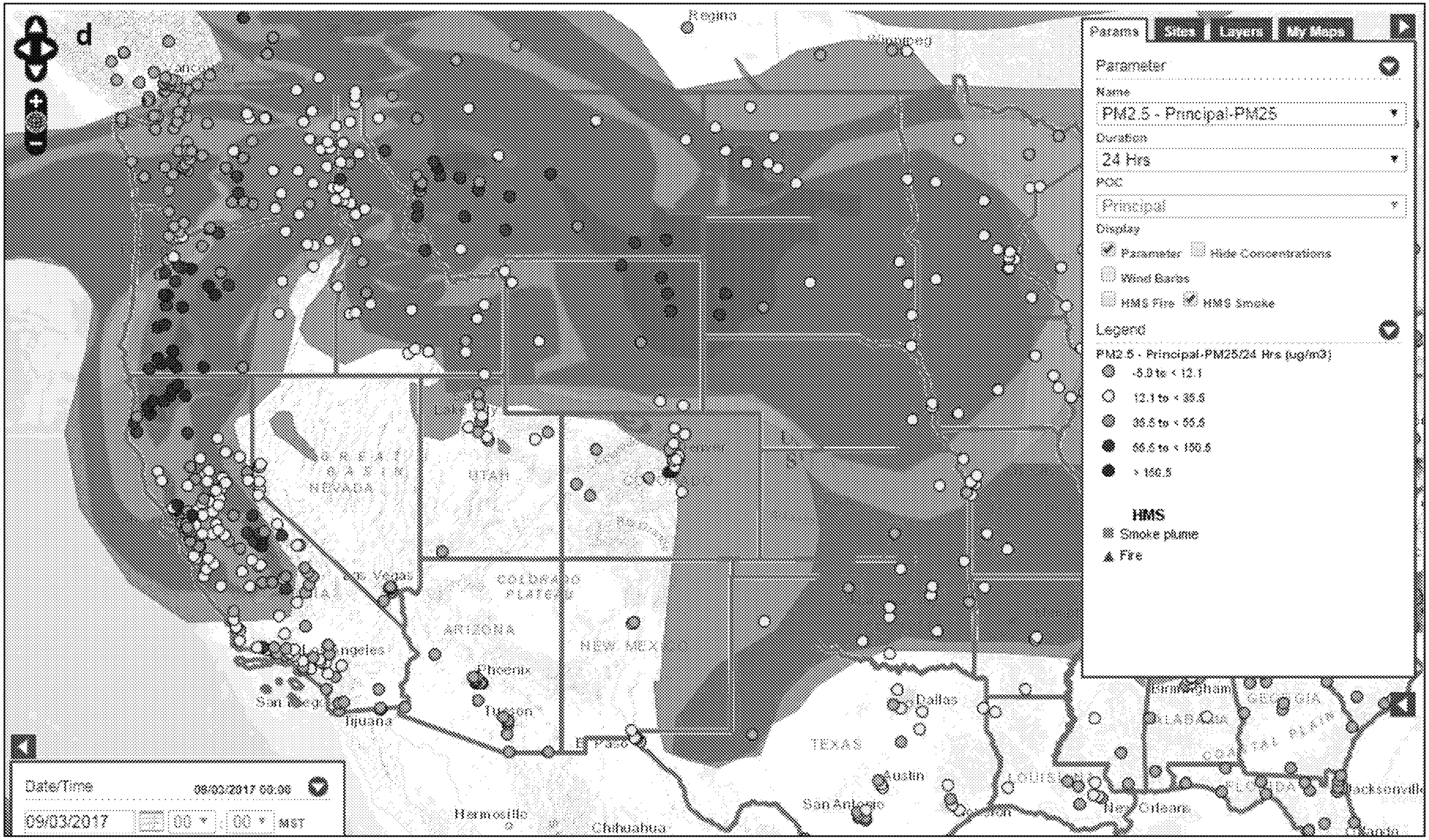


Figure 18d: HMS Smoke detection and 24-hr average $PM_{2.5}$ concentration on September 3, 2017. (source: https://airnowtech.org/navigator)

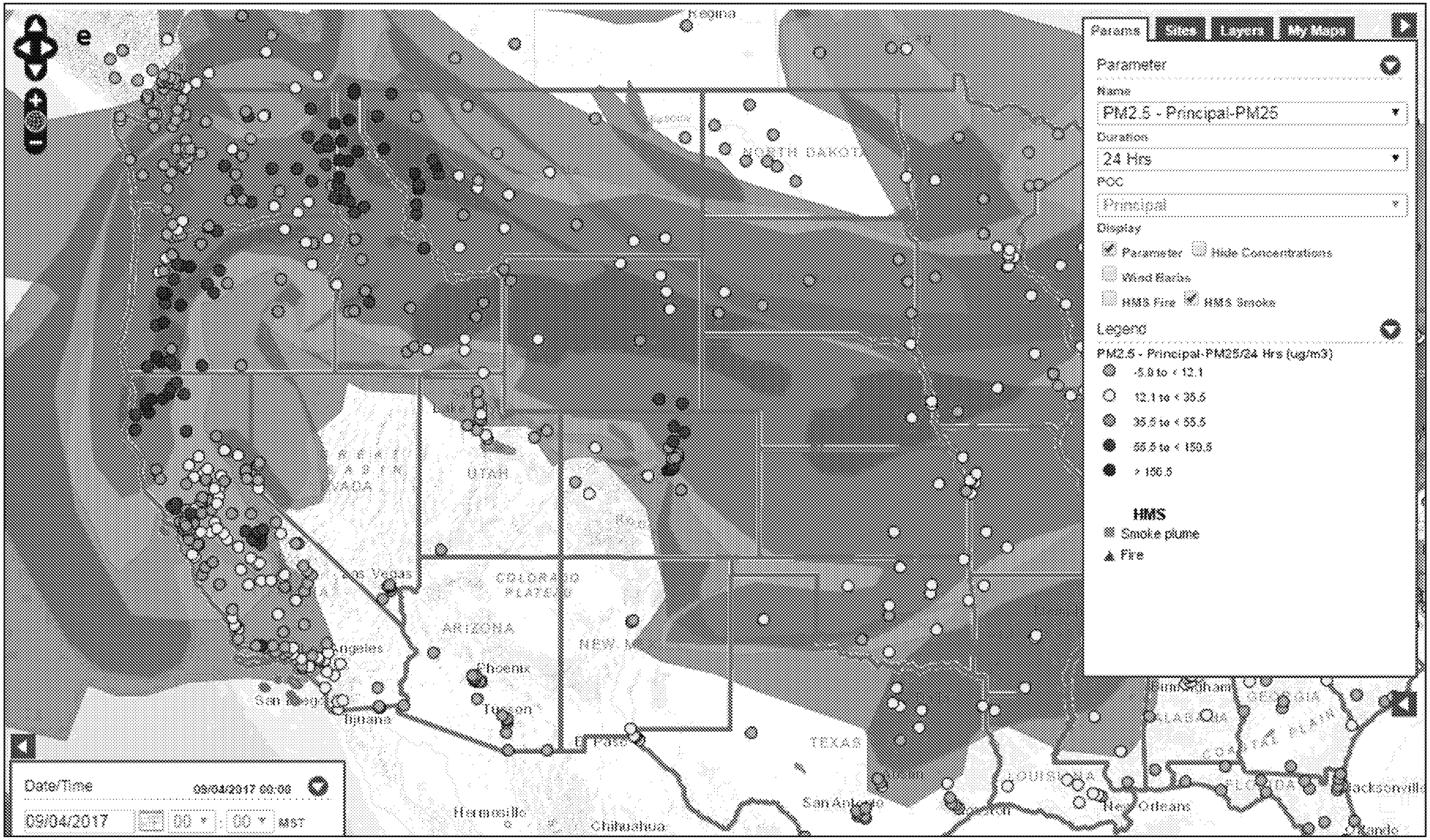


Figure 18e: HMS Smoke detection and 24-hr average $PM_{2.5}$ concentration on September 4, 2017. (source: https://airnowtech.org/navigator)

The extent and impact of the widespread wildfires and smoke throughout the country during this time period was published in a Wildfire Today article, by Bill Gabbert on September 17, 2017 (http://wildfiretoday.com/2017/09/17/looking-back-at-nifcs-june-prediction-for-august-september-wildfire-activity/). An excerpt from this article is below. Additional media coverage and social media posts are detailed in the Appendix A.

"Nationally, according to [National Interagency Fire Center] NIFC, 8.4 million acres have burned so far this year, which is 47 percent higher than the 10-year average to this date. Montana, which accounts for 1.2 million of those blackened acres, has been a focal point for seemingly endless fires producing staggering quantities of smoke. Combined with the smoke created by other fires in Idaho, Oregon, Washington, and northern California, the fouled air has affected residents across large sections of the country … A spokesperson for Montana's Department of Natural Resources and Conservation, Angela Wells, said "the period from June to August was the hottest and driest on record in Montana, and our fire season started about a month earlier than it usually does."

Figure 19 is a social media post from the U.S. National Weather Service (NWS) Grand Junction office on September 2, 2017, "Wondering where all the smoke and haze is coming from? Well this smoke is originating from wildfires mainly in Montana and to some extent Idaho that is being transported southward around a large area of high pressure to our west …"

At 2:57 AM MDT on September 2, 2017, the Denver/Boulder NWS Office area forecast discussion warned the area of reduced visibility and smoke; "… smoke from wildfires in Montana is expected to increase over eastern Colorado today and may reduce visibility to 5 to 10 miles." Smoke was confirmed during the 1:08 PM MDT Aviation forecast; "Hazy/smoky conditions remain over the region under light northerly flow aloft." Additionally, warnings of smoke in the region were issued in the forecast discussion of September 4, 2017 at 3:19 AM MDT, stating, "Smoke from wildfires will be thicker today and may slow heating. […] It will be a smoky day across the area due to the wildfires over Montana and the Pacific Northwest. Visibility is ranging from 3 to 6 miles across southeast Wyoming, western Nebraska, and over northeast Colorado. Expect this reduced visibility to persist through the morning and gradually improve through the afternoon." The forecast was continued in the 10:34 AM MDT discussion later than morning; "Main story today is the smoke. Large plum evident from GOES-16 imagery stretching from the Pacific NW across the Central Plains. The southern extent is now across most of the forecast area, and will be spreading into Park County later today. Air quality is poor to say the least.”. The detailed NWS forecast discussion from each day along with Descriptive Text Narrative products from the National Environmental Satellite, Data, and Information Service can be found in Appendix B.

Detailed study of the relationship between wildfire smoke and elevated O_3 has been documented in several scientific peer-reviewed journal articles, including examples of O_3 enhancement from both nearby wildfires as well as far from the fire location due to the buildup and transport of O_3 precursors within the smoke plume. Additionally, EPA’s Guidance highlights O_3-enhancing mechanisms and observations. Given that body of work as well as evidence of wildfire smoke O_3 enhancement noted in multiple exceptional event demonstrations already submitted to the EPA under this guidance, a detailed summary of how wildfire smoke leads to O_3 formation from a mechanistic standpoint is not necessary within the context of this demonstration. For details on previous research, see the State of Kansas Exceptional Event Demonstration Package April 6, 12, 13, and 29, 2011 (Kansas Department of Health and Environment, 2012) and the Sacramento Metropolitan Air Quality Management District demonstration requesting exclusions of 1-hr O_3 NAAQS exceedances due to wildfire smoke (California Air Resources Board, 2011). Other examples include multi-state demonstrations for O_3 exceedances due to smoke from the 2016 Fort McMurray wildfire (Connecticut Department of Energy and Environmental Protection, 2017; Massachusetts Department of Environmental Protection, 2017; New Jersey Department of Environmental Protection, 2017; Rhode Island Department of Environmental Management, 2017). Here, APCD details the clear causal relationship between wildfire smoke transport into the DM/NFR area and O_3 NAAQS exceedances, within the historical context of non-event O_3 in the DM/NFR area.

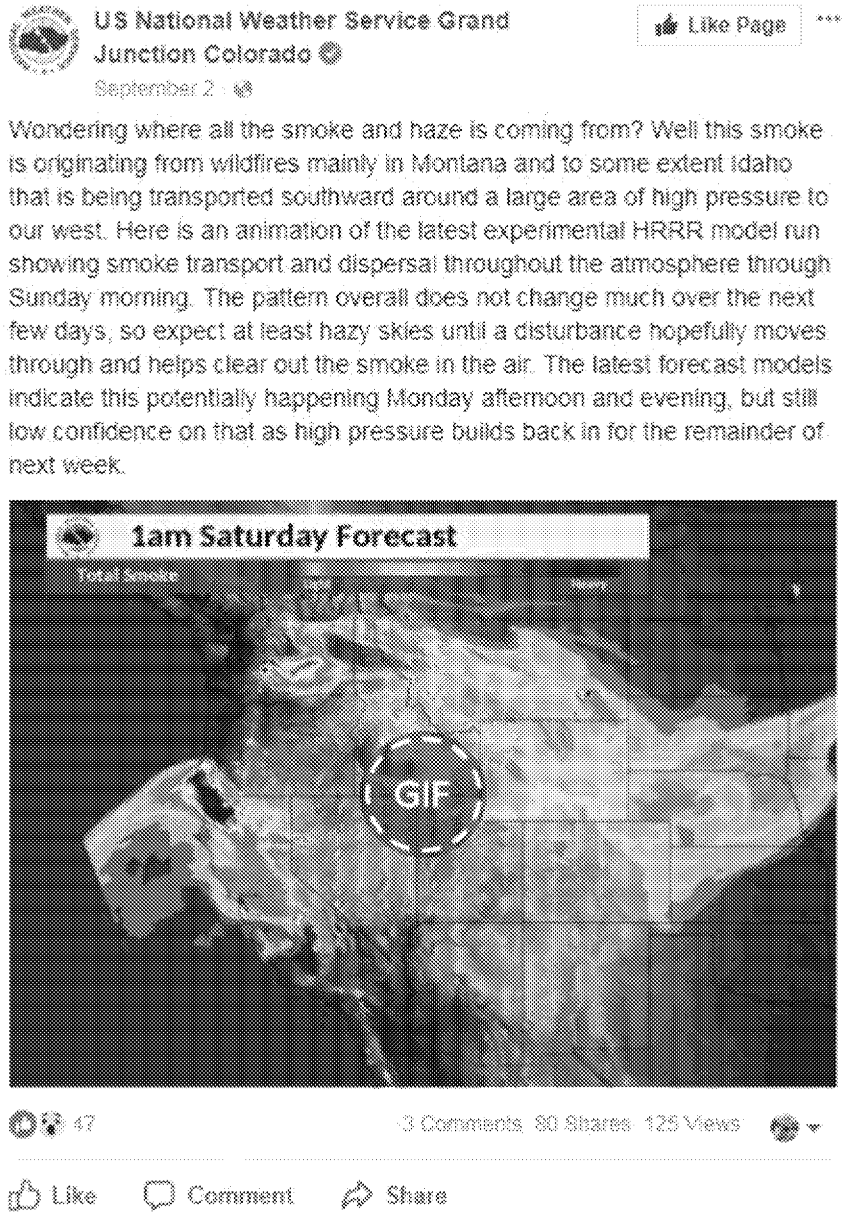


Figure 19: Grand Junction NWS office social media post on wildfire smoke in the region on September 2, 2017. (source: https://www.facebook.com/NWSGrandJunction/)

4.0 Clear Causal Relationship

4.1 Introduction

This section of the Exceptional Event demonstration details a technical analysis of the clear causal relationship between a widespread wildfire episode during the week of August 31–September 4, 2017 and the monitored exceedances, providing evidence that the episode adversely affected air quality. As specified in the EPA's 2016 EER revision, Guidance demonstrations should support the clear causal relationship. This includes: 1) evidence that the fire's emissions were transported to the monitor(s), 2) evidence that emissions from the wildfire influenced the monitored concentrations, and 3) quantification of the wildfire's emissions contributing to the monitored O_3 exceedance, and 4) a comparison of O_3 data requested for exclusion against historical O_3 concentrations at the affected monitor(s).

The Guidance defines a tier-based approach for demonstrations established by the episode's influence on O_3 and the level of evidence required to demonstrate a clear causal relationship between the episode and the exceedance. A Tier 2 approach is most appropriate for this wildfire smoke episode as described. Sections 4.2.1 and 4.2.2 detail Key Factor 1 and evidence of the presence of smoke. Section 4.3 details a historical analysis of this exceptional event in the context of five years of O_3 observations. This demonstration meets the requirements laid out in the Guidance and provides the evidence needed for EPA Region 8 to concur that an exceptional event episode occurred on September 2 and September 4, 2017.

4.2 Event Analysis

For each exceedance event day (September 2 and 4, 2017), this section will review meteorological conditions on the day, including forward and backward trajectories, identify wildfires whose smoke emissions are within the source region of the trajectories, provide additional evidence of the presence of smoke within the DM/NFR area, and include an analysis of wildfire smoke emissions with respect to distance from the fire location. Additionally, in Section 4.3, a historical analysis is provided, comparing the event days to historical O_3 and $PM_{2.5}$ data from within the DM/NFR area.

4.2.1 September 2, 2017 Exceedance

On September 2, 2017, seven O_3 monitors experienced high O_3 levels (at or above 68 parts per billion (ppb) averaged over an 8-hour period), with four of those monitors above the 70-ppb

O_3 2015 NAAQS, and one greater than the 75-ppb 2008 O_3NAAQS. The NREL monitor was the highest in the region at 76 ppb as seen in Figure 20.

To show the path and source of air that arrived at the monitor during the morning of the exceedance, back trajectories using the HYSPLIT analysis were run from NREL's location (for more information on HYSPLIT: https://ready.arl.noaa.gov/HYSPLIT.php). All back trajectories in this demonstration will use NREL's location, as the monitor exceeded the 2008 O_3NAAQS both days and it serves as a proxy for the DM/NFR area's airshed. Figure 21, initialized with both High-Resolution Rapid Refresh (HRRR) and Global Data Assimilation System (GDAS, which uses Global Forecast System, GFS) weather models, presents back trajectories from NREL at 500, 2000, and 3500 m above ground level (AGL), starting at 11 AM MST (18Z) on September 1, 2017 and ending 7 AM MST (12Z) September 2, 2017. These height levels are representative of the surface/low-level and mid-level flow in the atmosphere up to the steering winds at the top of the planetary boundary layer (PBL) during this time period. It should be noted that the lowest level was modelled at 500 m AGL as opposed to a level closer to the earth's surface. This process avoids any topographical or frictional layer bias that could negatively affect the model output.

Four wildfires were active in the northeastern Wyoming and southeastern Montana source region in the days preceding September 2, 2017: Cottonwood One, Tidwell, Brush Flat, and Sartin Draw (detailed reports on each fire can be found in Appendix B). Back trajectories at 3500 m AGL, shown in Figure 21, indicate a source region in the vicinity of the four wildfires. To verify smoke transport from this area, forward HYSPLIT trajectories were analyzed as a matrix at these four fires, starting 0z September 1, 2017 (5:00 PM MST 8/31/17) through 9Z September 2, 2017 (2:00 AM MST 9/2/17), as seen in Figure 22, and starting 0Z September 2, 2017 (5:00 PM MST 9/1/17) through 9Z September 2, 2017 (2:00 AM MST 9/1/17), as seen in Figure 23. A height of 2500 m AGL was used for both forward trajectories as this level is located just below the PBL, at the region of the fires, on both August 31 and September 1, 2017, as illustrated in Figure 24a-b. The PBL height acts a cap on the mixed layer in the troposphere; any smoke emitted below this level will mix up to that height and winds at that height will act as a steering force, transporting the smoke downwind. Smoke emissions from these fires on both August 31 and September 1, 2017 influenced the DM/NFR area's airshed on September 2, 2017. The forward trajectory analysis starting on August 31 indicates smoke emissions would enter northeastern Colorado overnight into September 2, 2017. The forward trajectory analysis starting on September 1 indicates smoke emissions entered western Nebraska overnight into September 2, 2017.

Additional evidence of smoke transport from these fires is demonstrated in (MODIS) Aqua True Color Satellite Imagery with Hazard Mapping System (HMS) fire detection on August 31 in Figure 25a, but especially on September 1 in Figure 25b. Furthermore, elevated total column carbon monoxide (CO) is illustrated in Figure 26 with concentrations in excess of 100 ppb in northeastern Colorado and western Nebraska at 12:52 PM MST on September 2, 2017. Smoke emitted from these four fires with significant amounts of CO follows a path similar to the forward trajectories in Figure 22.

High Aerosol Optical Depth (AOD) is also observed across northeastern Colorado and western parts of Nebraska on the morning of September 2, 2017, as seen in Figure 27. For a closer look at AOD in Colorado, Figure 28 is the MODIS Terra AOD at 11 AM MST on September 2, 2017, with North American Model (NAM) analysis surface wind vectors. High AOD indicates an optically thick aerosol layer, in this case wildfire smoke. Figure 28 suggests that smoke in northeastern Colorado and western Nebraska was transported by northeasterly surface winds into the DM/NFR area. Figure 29 shows that the smoke moved into an air mass with a shallow boundary layer of 1000-2000 meters ABL. Note, the lowest boundary layer heights can be found in areas near the Front Range and Palmer Divide foothills within the DM/NFR area where the highest O_3 concentrations were measured. Visual evidence of ground-level smoke is presented in the webcam image in Figure 30, from CDPHE's live image on 10:57 AM MST on September 2, 2017. For comparison, a smoke-free image from the same date two years prior is presented in Figure 31, taken at 10:57 AM MST on September 2, 2015.

APCD maintains an aethalometer at one of its 'near road' sites located near the junction of I-25 and Yuma St., in central Denver. An aethalometer is a continuous instrument that measures the concentration of optically absorbing black carbon particles in ambient air. The proximity of the site to the major north-south Interstate in Denver suggests that in addition to the ambient background the sample will be strongly affected by vehicle emissions, especially particulates from diesel-powered vehicles. Figure 32, demonstrates a typical sample day, in this case from August 30, 2017, three to five days prior to the exceedance days. The units are in ng/m^3. The presence of smoke is indicated by the presence of 'separation' between absorption at shorter wavelengths (i.e. 370 nm) and absorption at longer wavelengths (Zhang K.M., et al., 2017). That indicative separation is not present in Figure 32. However, as presented in Figure 33, in the aethalometer data for September 2, 2017, there is separation between the shorter and longer wavelengths, indicating the presence of ground-level smoke within the DM/NFR area.

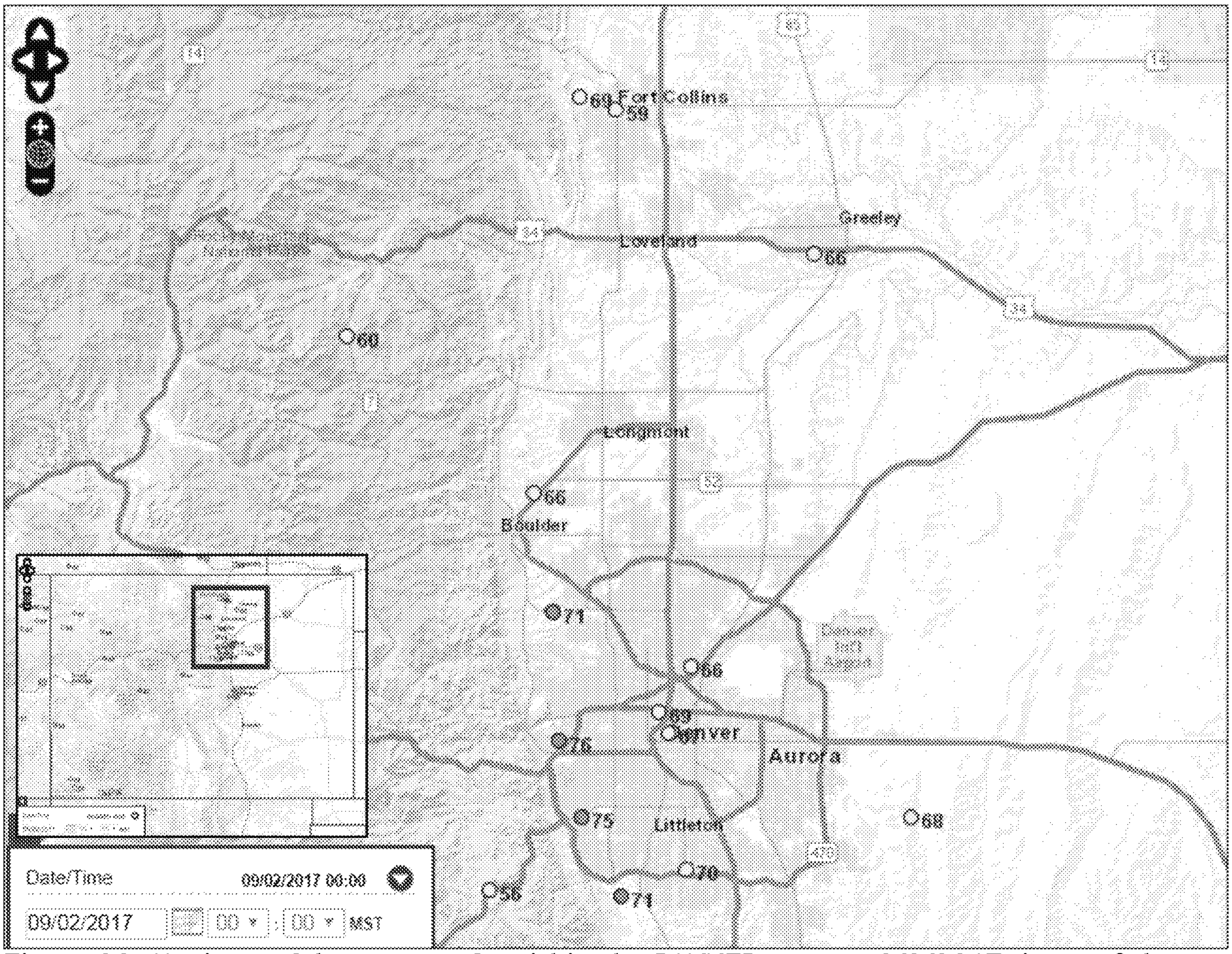


Figure 20: Maximum 8-hr average O_3 within the DM/NFR area on 9/2/2017, inset of the State of Colorado for geographical reference (source: https://airnowtech.org/navigator/)

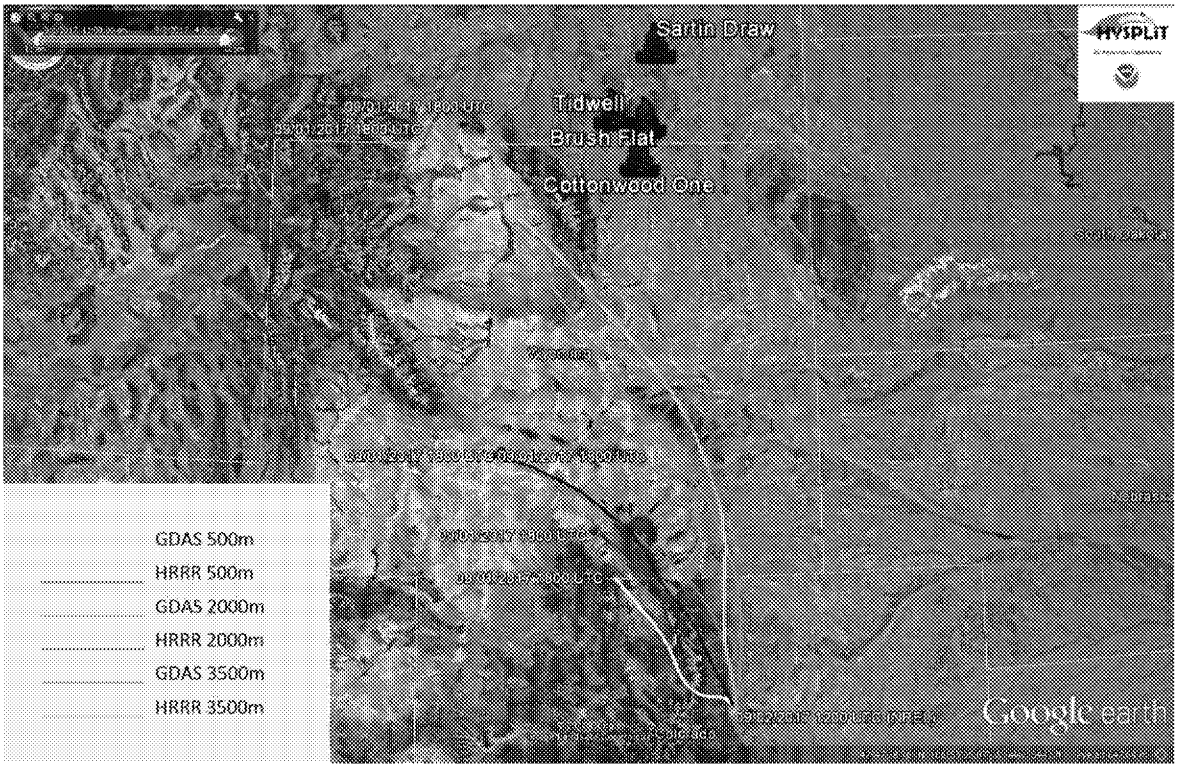


Figure 21: HRRR and GDAS 18-hour HYSPLIT back trajectories starting at 7 AM MST (12Z) September 2, 2017. (source: https://ready.arl.noaa.gov/HYSPLIT.php)

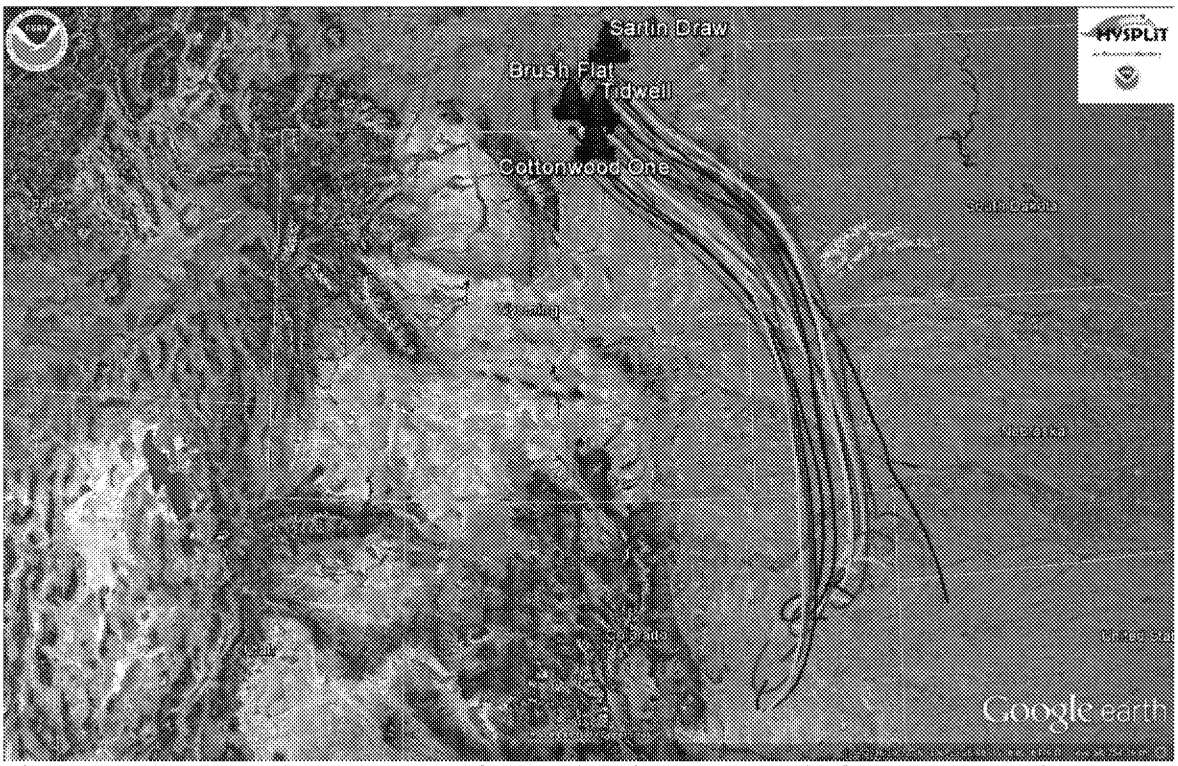


Figure 22: GDAS 33-hour HYSPLIT forward trajectory matrix from NE Wyoming/SE Montana wildfires at 2500 meters AGL, starting at 5 PM MST (0Z September 1, 2017) August 31, 2017 and ending at 2 AM MST (9Z) September 2, 2017.(source: https://ready.arl.noaa.gov/HYSPLIT.php)

Figure 23: GDAS 9-hour HYSPLIT forward trajectory matrix from NE Wyoming/SE Montana wildfires at 2500 meters AGL, starting at 5 PM MST (0Z September 2, 2017) September 1, 2017 and ending at 2 AM MST (9Z) September 2, 2017. (source: https://ready.arl.noaa.gov/HYSPLIT.php)

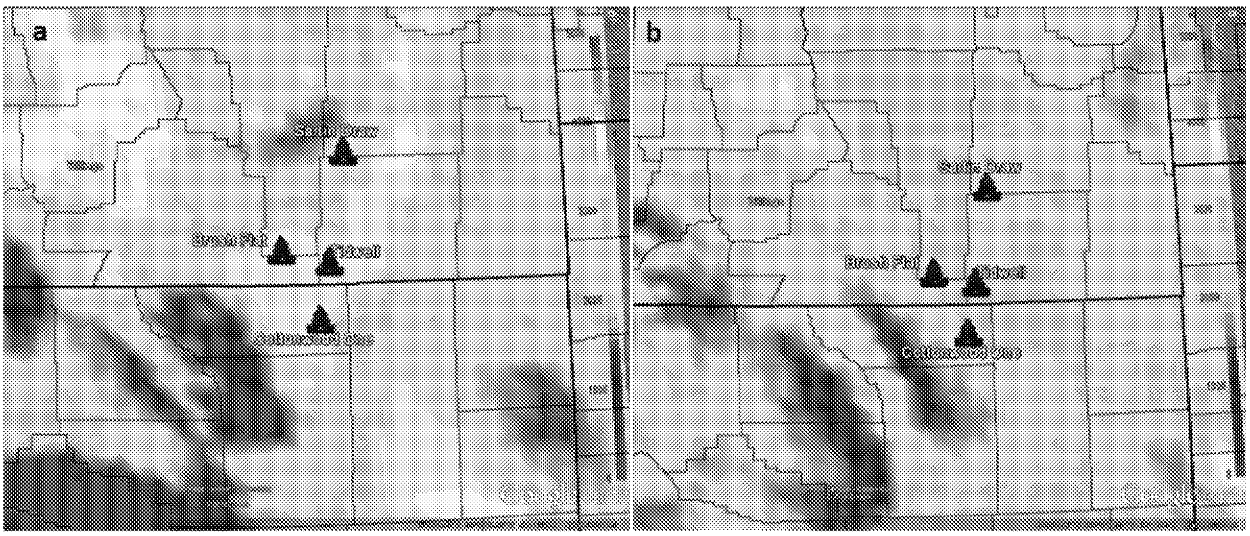


Figure 24a-b: NAM Analysis Planetary Boundary Layer height in meters AGL, (a) 2 PM MST (21Z) August 31, 2017, and (b) 2 PM MST (21Z) September 1, 2017. (source: https://nomads.ncdc.noaa.gov/thredds/catalog.html)

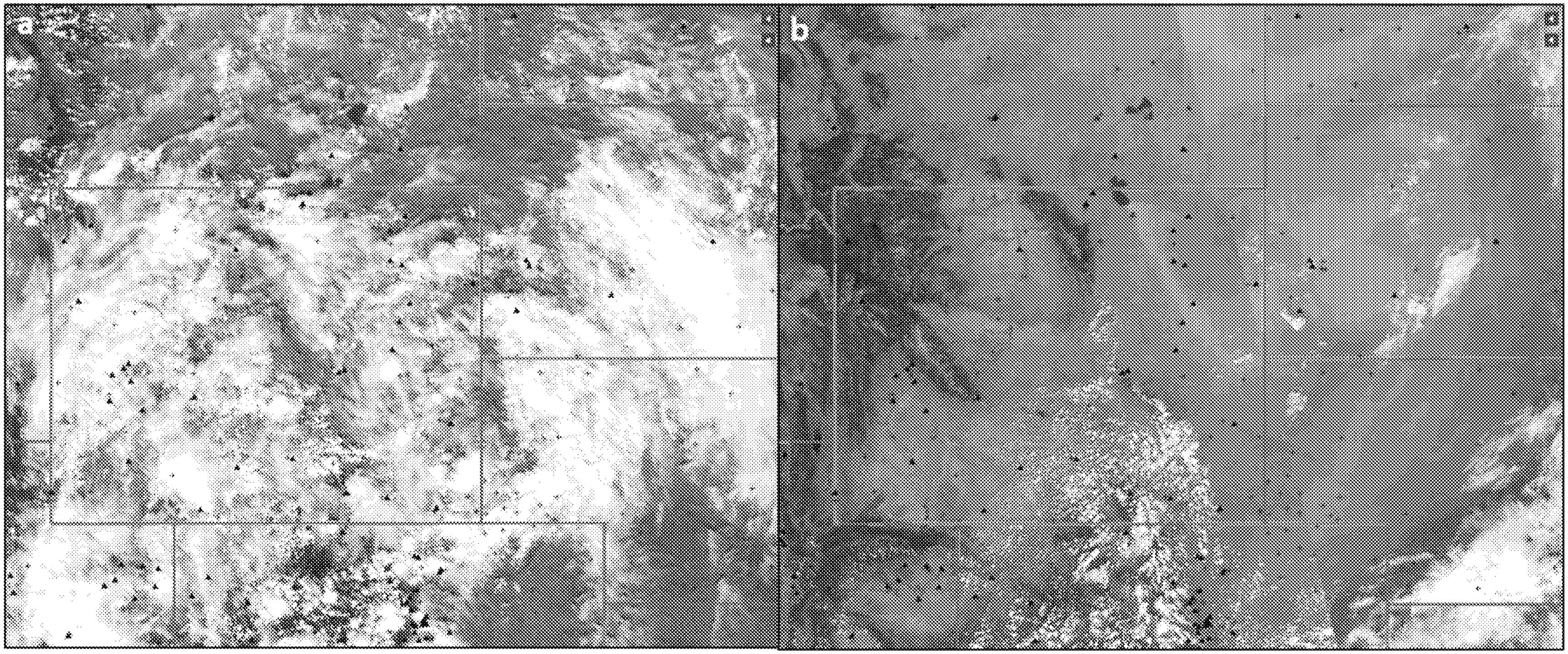


Figure 25a-b: MODIS Aqua image with Hazard Mapping System (HMS) detected hot spots, (a) August 31, 2017 at approximately 1:07 PM MST (1807Z),and (b) September 1, 2017 (combined image of two satellite passes with western half of the image at approximately 1:50 PM MST (2050Z) and the eastern half of the image at approximately 12:10 PM MST (1910Z). (source: https://airnowtech.org)

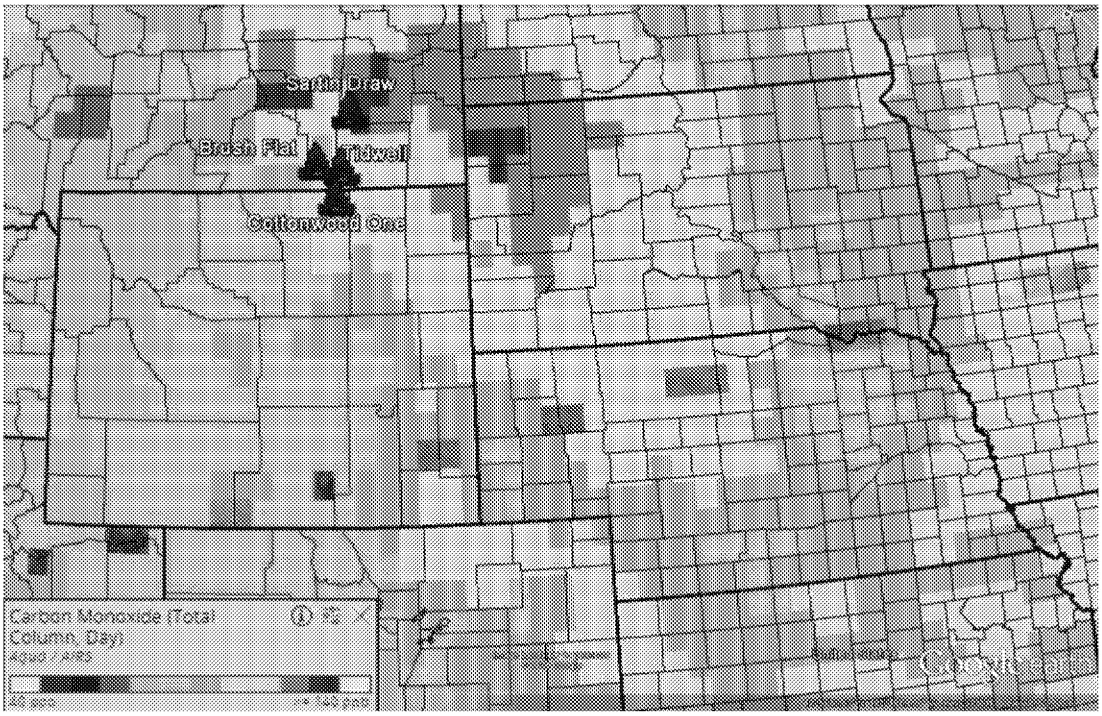


Figure 26: AIRS Aqua Total Column CO at approximately 12:52 PM MST (1952Z) September 2, 2017. (source: https://worldview.earthdata.nasa.gov/)

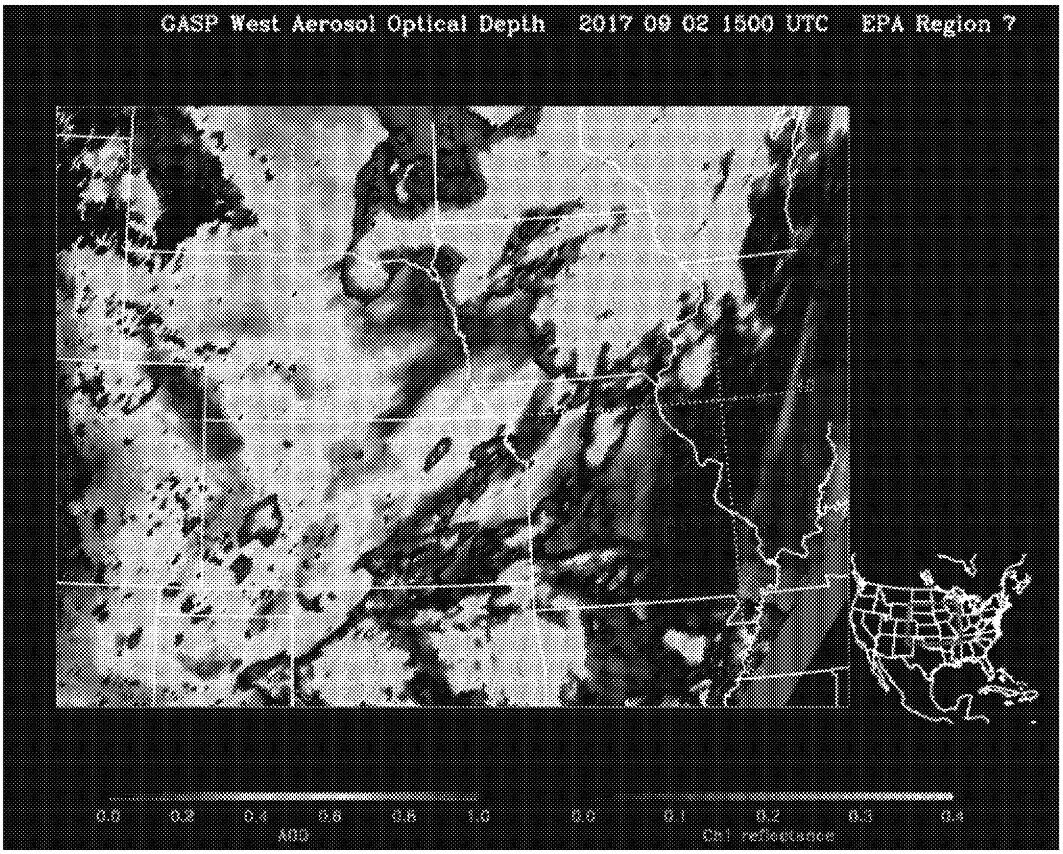


Figure 27: GOES Aerosol Smoke Products West AOD, EPA Region 7, 8:00 AM MST (15Z) September 2, 2017. (source: https://www.star.nesdis.noaa.gov/smcd/spb/aq/)

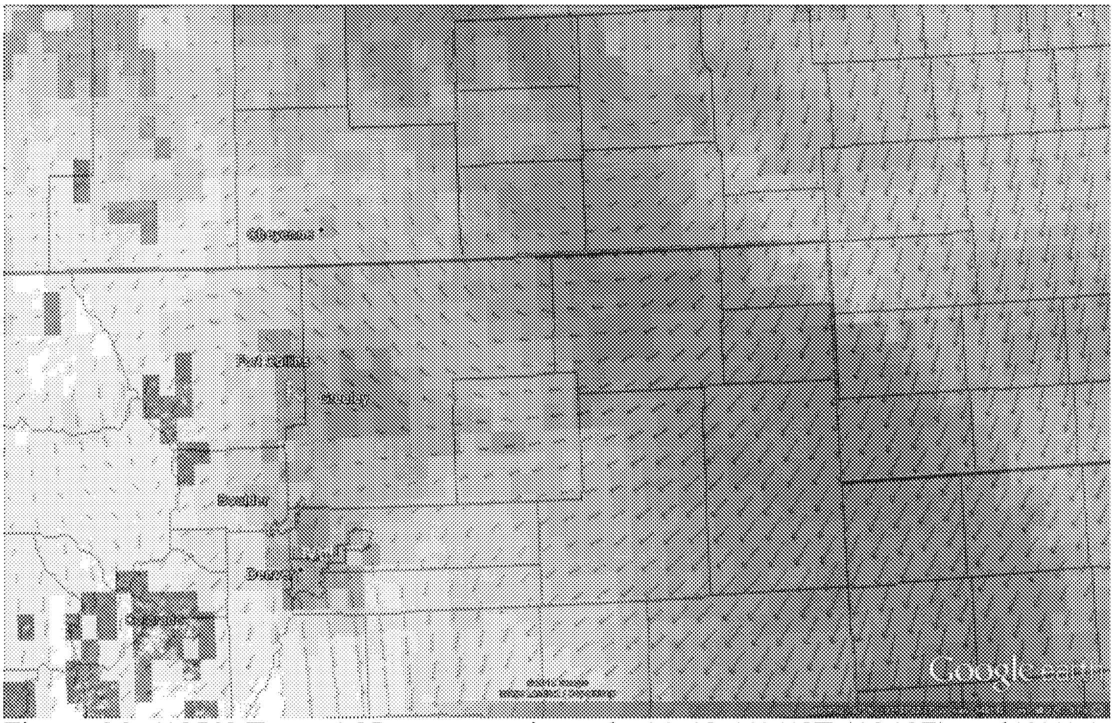


Figure 28: MODIS Terra AOD at approximately 11:12 AM MST (1812Z) and NAM Analysis wind vectors at 11:00 AM MST (1800Z) on September 2, 2017. (source: https://worldview.earthdata.nasa.gov/)

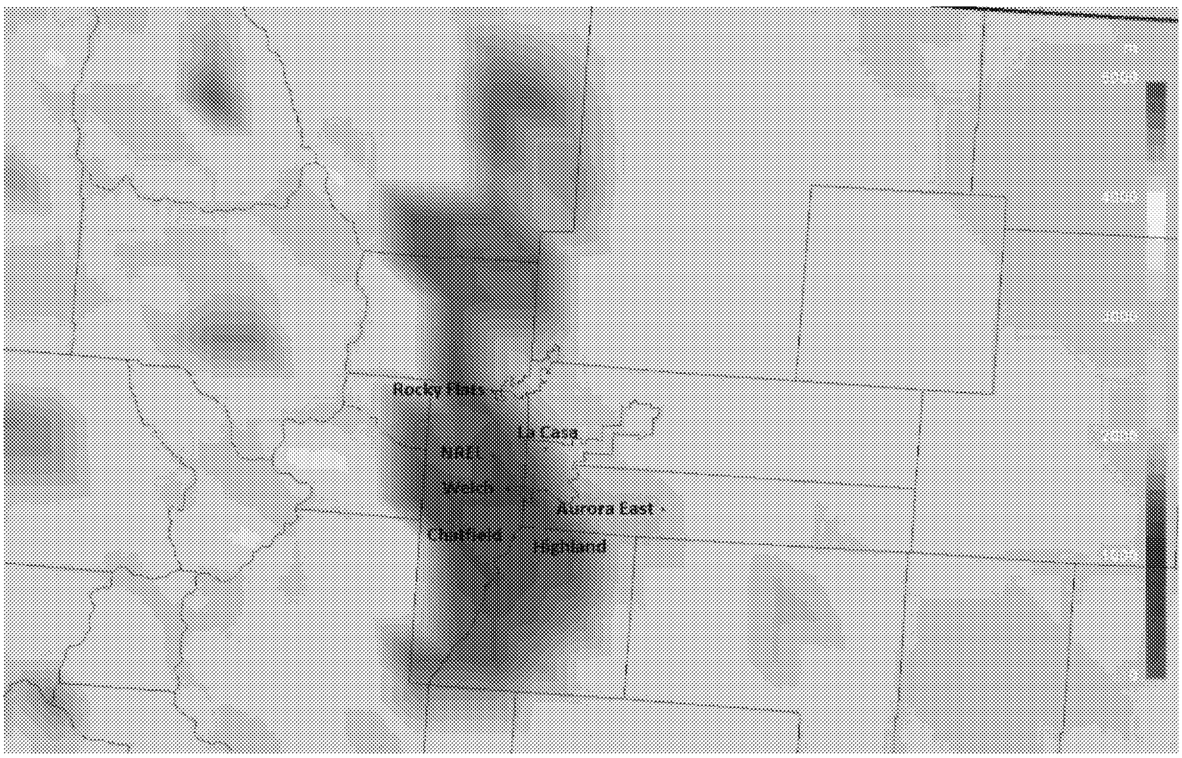


Figure 29: NAM Analysis Planetary Boundary Level height in meters AGL, 2:00 PM MST (21Z) September 2, 2017. (source: https://nomads.ncdc.noaa.gov/thredds/catalog.html)

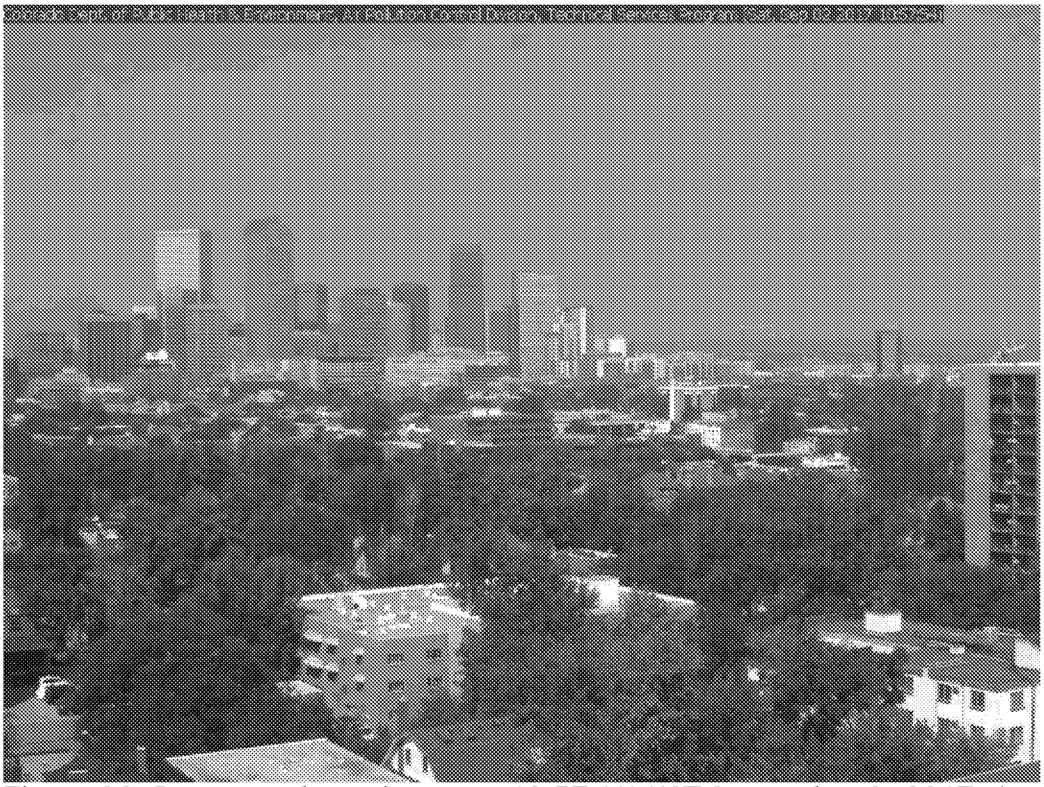


Figure 30: Denver webcam image at 10:57 AM MST September 2, 2017. (source: https://www.colorado.gov/airquality/live_image.aspx**)**

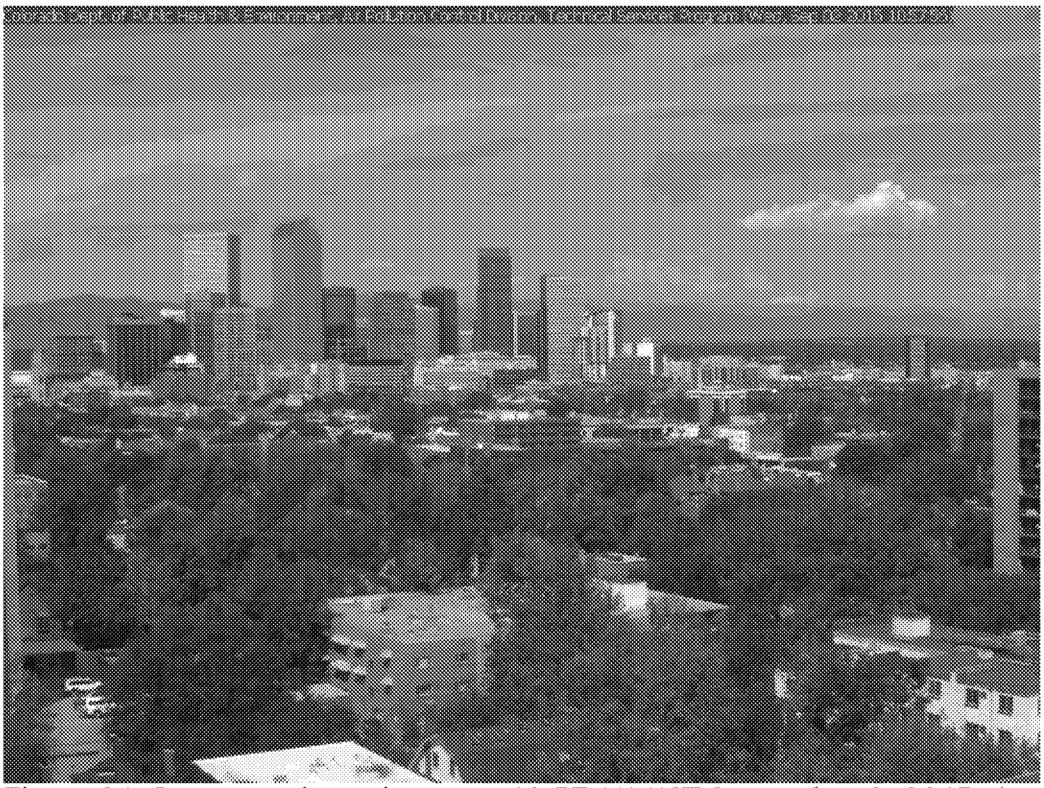


Figure 31: Denver webcam image at 10:57 AM MST September 2, 2015. (source: https://www.colorado.gov/airquality/live_image.aspx**)**

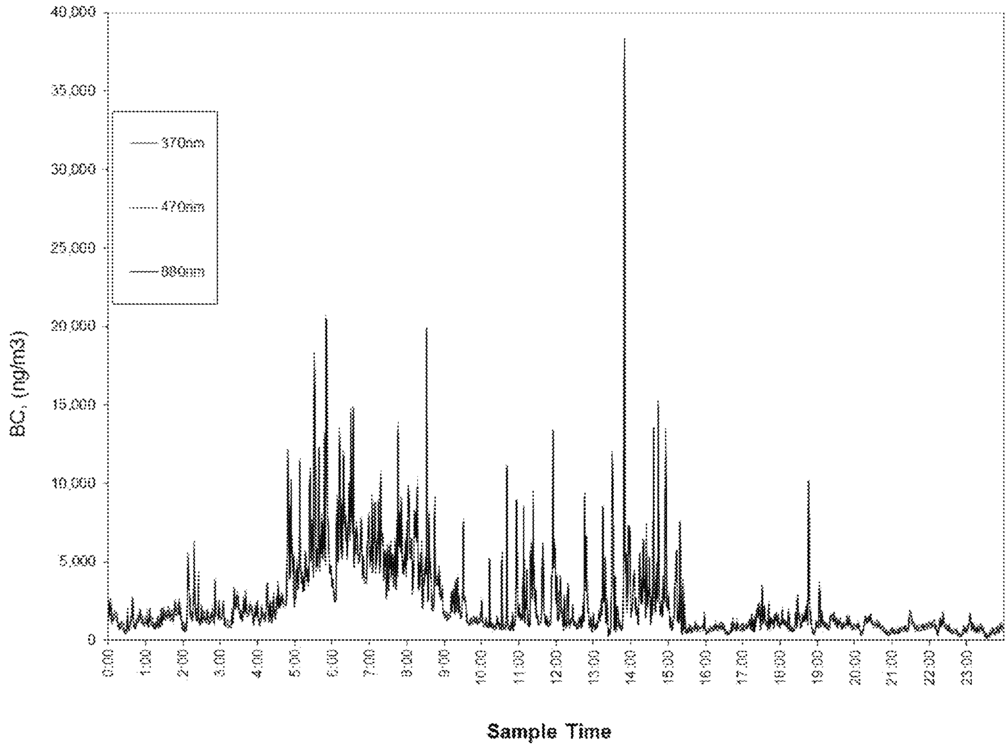


Figure 32: Black carbon absorption from APCD's near-road aethalometer measurement in central Denver on August 30, 2017.

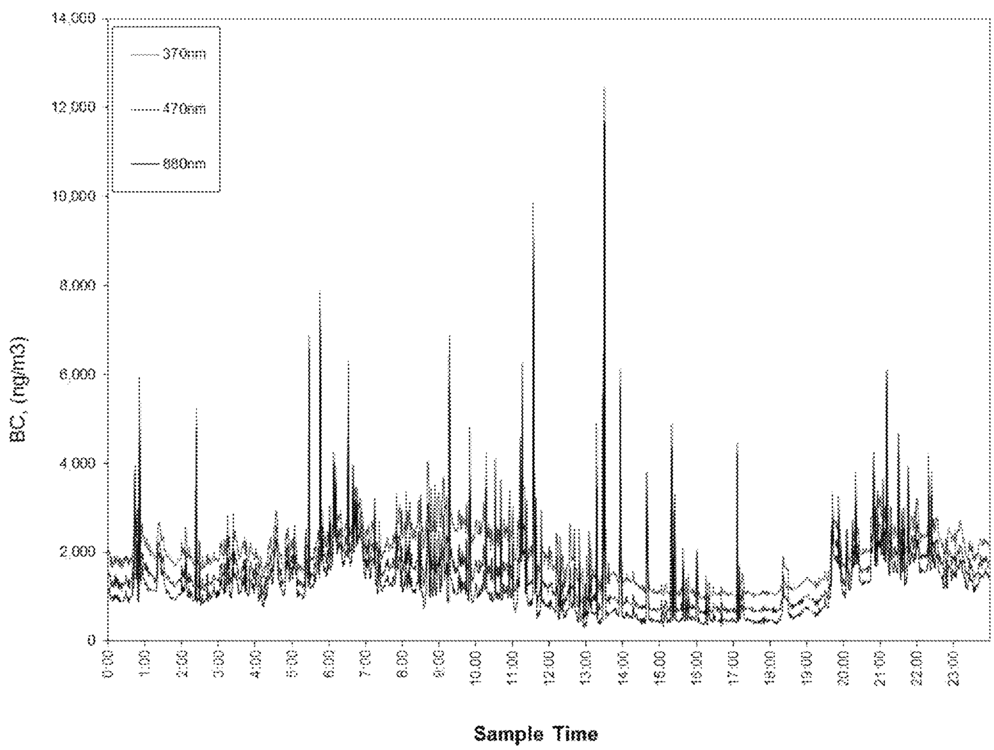


Figure 33: Black carbon absorption from APCD's near-road aethalometer measurement in central Denver on September 2, 2017.

Trajectories, as well as satellite and surface observations in the previous figures establish that smoke from wildfires in northeastern Wyoming and southeastern Montana was transported to the DM/NFR area and was present at the identified monitor locations during the O_3 exceedances of September 2, 2017. Most impactful on the September 2, 2017 O_3 exceedance event were smoke emissions from this region on August 31 and September 1, 2017. During this period, four wildfires were reported: Cottonwood One in Wyoming, and Tidwell, Brush Flat, and Sartin Draw in Montana. Information regarding each wildfire's development was gathered from a number of sources. High-resolution maps with infrared (IR) detection for fire parameters were used as the primary source to determine daily acres burned information. In most cases, these types of maps were available through Inciweb (https://inciweb.nwcg.gov/). When detailed daily emergency response briefing maps were not available, agency reports, news releases, and social media were compiled from various sources that demonstrate clear evidence of fire growth. This information is available in Appendix B.

Over 170,000 cumulative acres burned on August 31 and September 1, 2017 in these four wildfires, none of which were human caused. While not one individual fire in this region crossed into 'mega-fire' status (over 100,000 acres), fire growth and development during these days was extreme. Dangerous fire weather was observed on August 31, 2017 as well as overnight into September 1, 2017 and throughout the day in northeastern Wyoming and southeastern Montana, as evidenced in Figure 34a-d with sustained west to northwest surface winds at or above 15 mph and relative humidity dipping well below 30%. Miles City, MT, the closest weather observation station to Sartin Draw, experienced a high temperature of 96˚F, a minimum relative humidity of 14%, with maximum wind speed of 23 mph and maximum wind gust of 29 mph on August 31, 2017. At the same location on September 1, 2017 the high temperature reached 84˚F, a minimum relative humidity of 22%, with maximum wind speed of 20 mph and maximum wind gust of 23 mph.

Based on EPA's Guidance, a Tier 2 approach is most appropriate to suffice the clear causal relationship requirement. This approach necessitates an analysis of NO_x and VOC emissions (Q) from relevant wildfires compared to distance (D) in kilometers from the affected monitor to the wildfire location. The U.S. Forest Service AirFire Bluesky Playground v2.0 *beta* program was used to model NO_x and VOC emissions from these four fires on August 31 and September 1, 2017. Locations used to model each fire was based on the latitude and longitude of the ignition point as reported in Inciweb. If fire location information was unavailable in Inciweb, intelligence and dispatch reports were utilized from regional offices of the Geographic Area Coordination Centers (https://gacc.nifc.gov/). Fuel types were determined from LANDFIRE's Fuel Characteristic Classification System (FCCS) based on fire location. Fuel moisture content was modeled as "very dry" determined by long-term drought conditions, coupled with above normal temperatures and below normal precipitation in the region over the two months prior to this episode. Emissions from each fire for each day (Q) is the sum of NO_x and VOC emissions from that fire for acres burned during that day. In the case of multiple fires, EPA's Guidance suggests using an emissions weighted distance for D. Thus, determining total Q/D as the sum of NO_x and VOC emissions from each fire on each day, divided by the emissions weighted distance (detailed in EPA's Guidance). Table 11 contains pertinent information for determining overall Q/D for the September 2, 2017 O_3 exceedance. Aggregating fires over the two days in the source region affecting the DM/NFR area's O_3 resulted in a Q/D of 224.9, largely surpassing the Q/D greater than 100 threshold suggested by EPA's Guidance.

Technical analysis of the clear causal relationship between wildfire smoke and O_3 exceedance in the DM/NF area on September 2, 2017 has been demonstrated by examining the meteorological conditions, transport winds and trajectories, wildfire locations and emissions, as well as additional evidence of smoke at the impacted monitors using satellite and ground observations. Accordingly, this demonstration provides sufficient evidence that these fire emissions were transported to the monitors and the wildfires influenced the monitored concentrations, as well as quantification of the wildfire's emissions that contributed to the monitored O_3 exceedances on September 2, 2017.

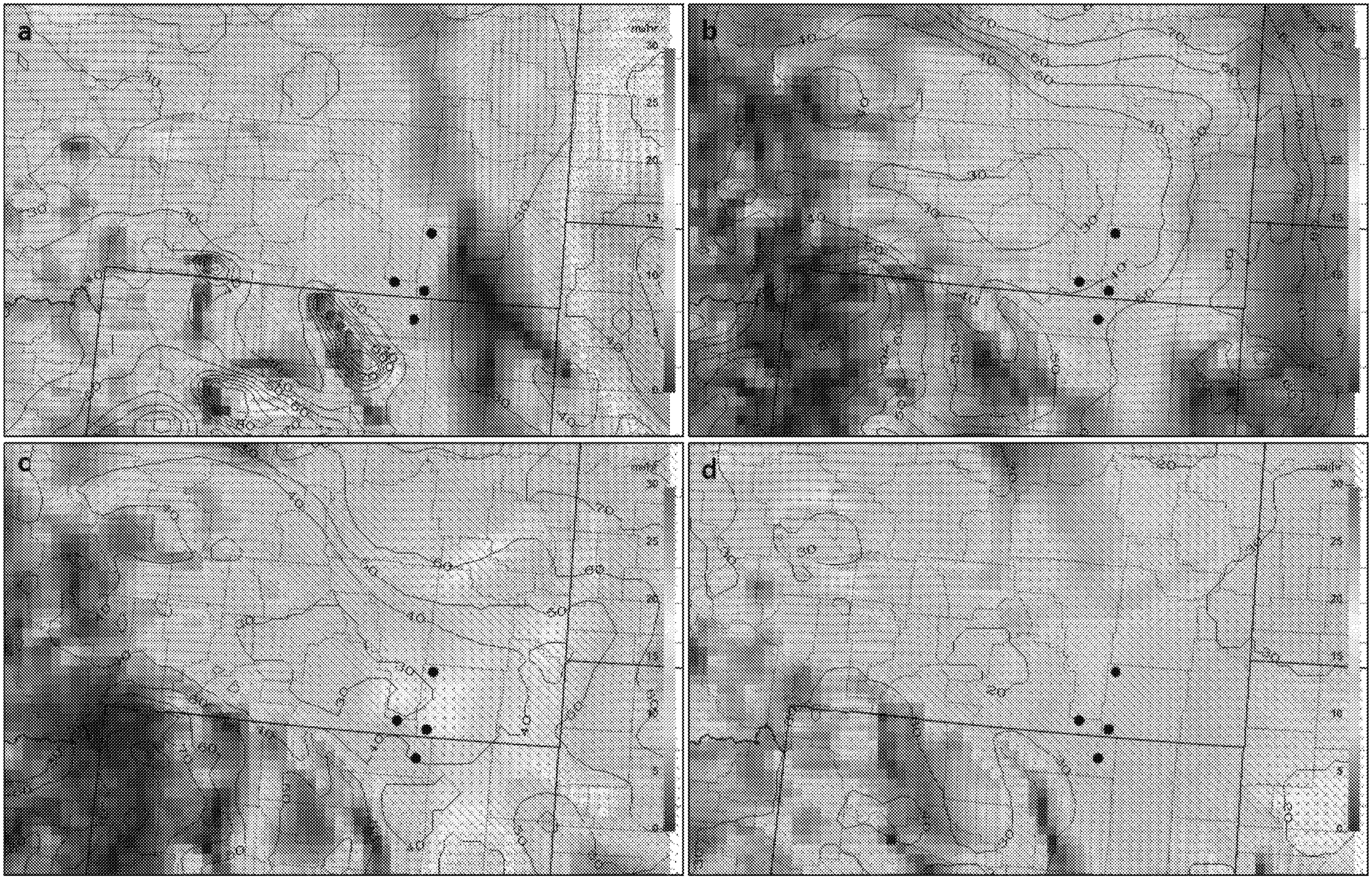


Figure 34a-d: Surface relative humidity isopleths, wind vectors, and wind speed color contours from NAM analysis with fire locations (black dots) at (a) 2:00 PM MST (21Z) August 31, 2017, (b) 5:00 AM MST (12Z) September 1, 2017, (c) 8:00 AM MST (15Z) September 1, 2017, (d) 2:00 PM MST (21Z) September 1, 2017.

Table 11: Wildfire information for fires affecting September 2, 2017 O_3 exceedances.

Fire	Lat	Long	Cause	Burned on	Acres Burned	NOx (tpd)	VOCs (tpd)	Distance (km)	Q (tpd)	Q/D (tpd/km)
Cottonwood One	44.682	-106.252	*unknown*	8/31/17	3500	77.4	3743.2	556.23	3820.6	6.9
Tidwell	45.042	-106.158	*lightning*	8/31/17	10000	221.0	10694.8	594.71	10915.9	18.4
Brush Flat	45.123	-106.586	*lightning*	8/31/17	20000	149.8	1231.4	609.24	1381.2	2.3
Sartin Draw	45.739	-106.009	*natural*	8/31/17	72130	4204.2	99010.1	670.13	103214.3	154.0
Cottonwood One	44.682	-106.252	*unknown*	9/1/17	656	14.5	701.6	556.23	716.1	1.3
Tidwell	45.042	-106.158	*lightning*	9/1/17	7160	158.3	7657.5	594.71	7815.8	13.1
Brush Flat	45.123	-106.586	*lightning*	9/1/17	53285	399.0	3280.8	609.24	3679.8	6.0
Sartin Draw	45.739	-106.009	*natural*	9/1/17	11000	641.2	15099.3	670.13	15740.4	23.5
				SUM	177731.0	5865.3	141418.7		147284.0	225.5
					Emissions Weighted Distance (km)				654.94	
					Q/Emissions Weighted Distance				**224.9**	

4.2.2 September 4, 2017 Exceedance

On September 4, 2017, nine O_3 monitors experienced high O_3 levels (at or above 68 ppb averaged over an 8-hour period), with six of those monitors above the 70 ppb O_3 2015 NAAQS, and two greater than the 75 ppb O_3 2008 NAAQS. The RFN monitor was the highest in the region at 78 ppb as seen in Figure 35.

To assess the source region of the air in the DM/NFR area during the high O_3 episode of the afternoon of September 4, 2017, a 48-hr HYSPLIT back trajectory is presented in Figure 36. It was initialized with GDAS meteorological data at 500, 1000, and 1500 m AGL, starting 21Z on September 2, 2017 (2:00 PM MST 9/2/17) and ending 21Z September 4, 2017 (2:00 PM MST 9/4/17), revealing the northwestern U.S. as a potential source region. The height levels modeled appear to be an accurate representation of the surface/low-level and mid-level flow in the atmosphere over the source region, with PBL heights for the northwestern U.S. during the initialization time mainly below 2000 m AGL during (Figure 37). As this trajectory covers a large region of the northwestern U.S., an additional HYSPLIT run using HRRR meteorological data was executed. Figure 38 illustrates both HRRR and GDAS for this same 48-hr time period including active fires on September 2, 2017, the starting time of the back trajectory analysis. Two major source regions of active wildfires emerged including 24 active wildfires during the back trajectory time period: (a) central Washington (Figure 39a) and (b) northern Idaho and western Montana (Figure 39b). During this same time period, the Big Red fire was active in northern Colorado. To verify that smoke from this Colorado fire affected the DM/NFR area, an 18-hr GDAS HYSPLIT forward trajectory was analyzed from the ignition point of the Big Red fire starting at 5:00 PM MST, September 3, 2017 (Figure 40). The PBL height in the vicinity of the Big Red fire was 3000-4000 m AGL during the afternoon of September 3, 2017 (Figure 41). Therefore, forward trajectories from the Big Red fire were modelled at 2000, 2500 and 3000 m AGL. These levels effectively capture the transport winds below the PBL but also keeps the trajectories high enough to most effectively traverse the complex terrain of north-central Colorado. Forward trajectories from the Big Red fire clearly show smoke transport from the fire the afternoon of September 3, 2017 arriving to the DM/NFR area by the late morning of September 4, 2017.

The progression of fires and smoke emissions from September 2-4, 2017 is shown with MODIS Aqua True Color Satellite Imagery and HMS fire detection in Figure 42a-c. Smoke from wildfires in Washington, Idaho and western Montana was directed by west to northwest transport winds, as described in Section 3.3, and transported east and southeastward into eastern Montana and northeastern Wyoming during the September 2-3, 2017 time period. Smoke concentrated and pushed southeastward overnight September 3 into September 4, 2017 as a cold front moved through Montana, into Wyoming and eventually northeastern Colorado as seen in both Figure 42b-c, as well as in the surface weather analysis in Figures 43a-d. Visual evidence of ground-level smoke in the DM/NFR area is presented in the CDPHE live webcam image in Figure 44a-b, showing heavy smoke in Denver on the morning of September 4, 2017 (Figure 44a) and thickening throughout the day (Figure 44b). Additional smoke evidence is demonstrated by black carbon aerosols measurements in Figure 45 from APCD's aethalometer data in Denver on September 4, 2017, where separation between shorter and longer wavelengths is observed, confirming the presence of smoke throughout the day.

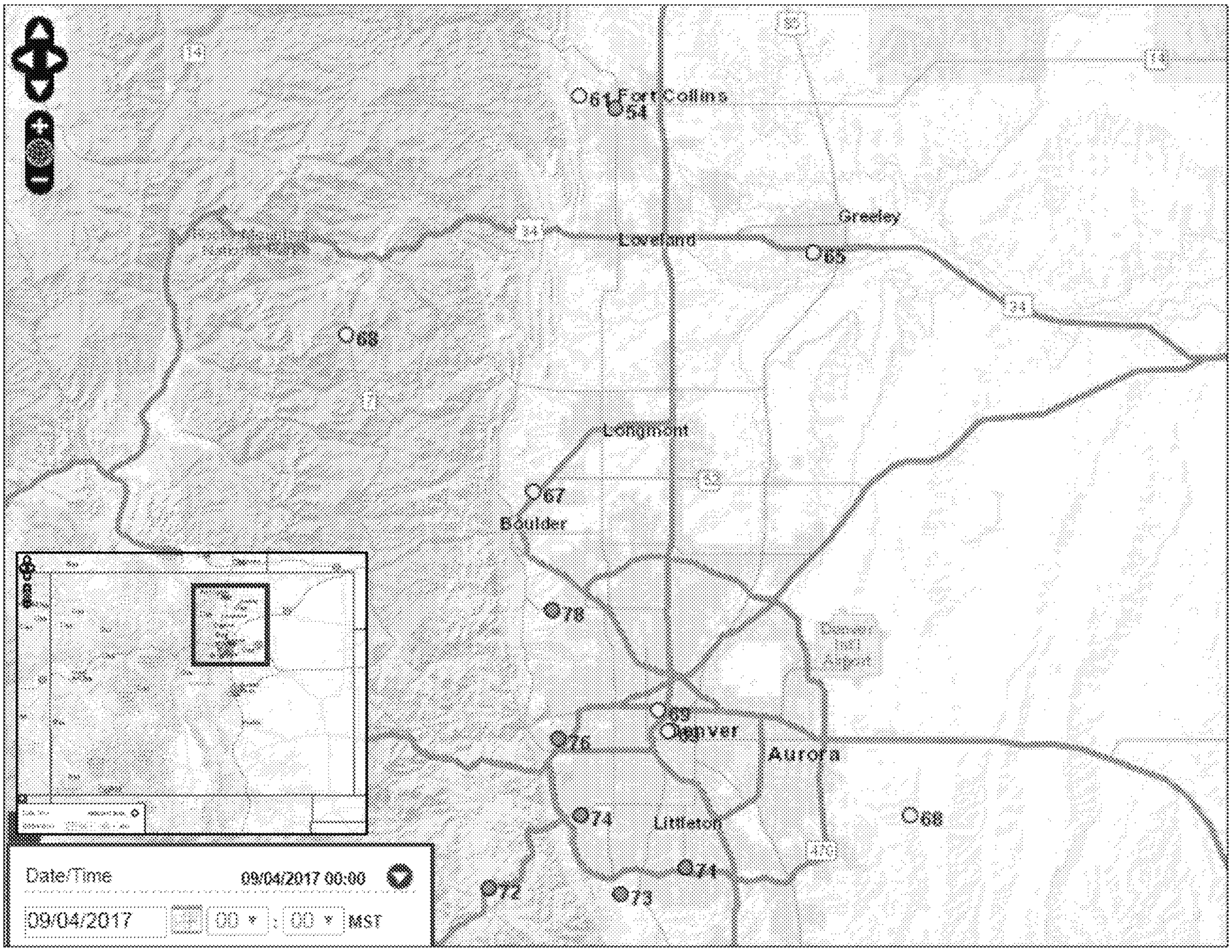


Figure 35: Maximum 8-hr average O_3 within the DM/NFR area on 9/4/2017, inset of the State of Colorado for geographical reference (source: https://airnowtech.org/navigator/)

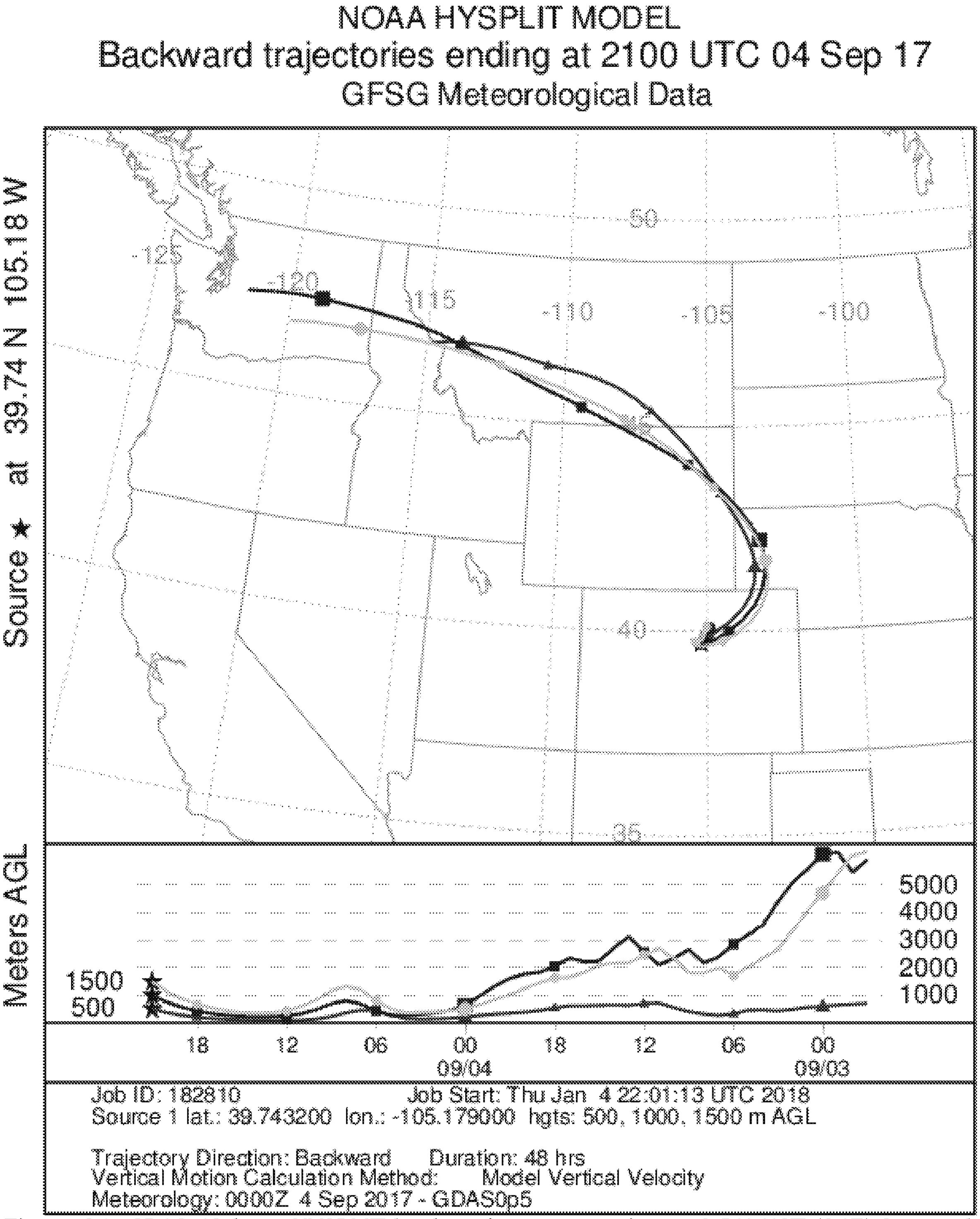


Figure 36: GDAS 48-hour HYSPLIT back trajectory starting at 2 PM MST (21Z) September 2, 2017 and ending at 2 PM MST (21Z) September 4, 2017. (source: https://ready.arl.noaa.gov/HYSPLIT.php)

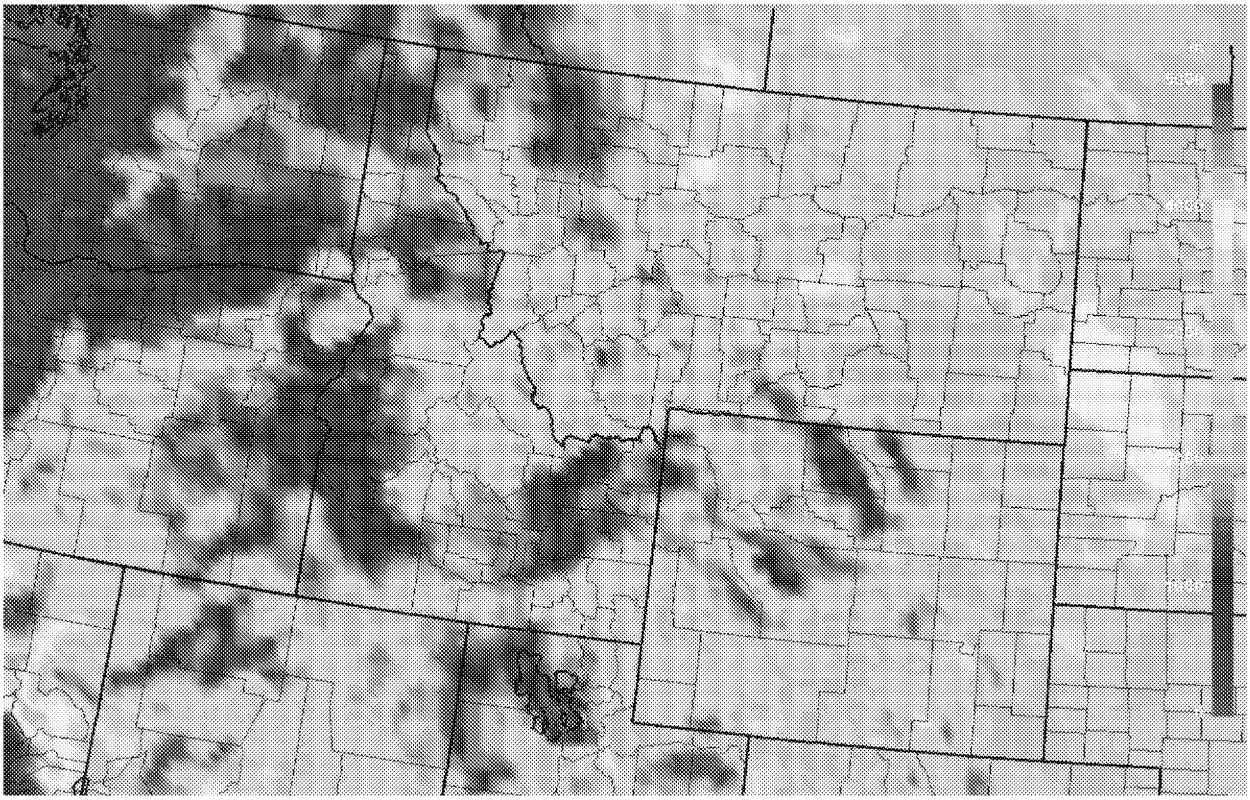


Figure 37: NAM Analysis Planetary Boundary Level height in meters AGL at 2:00 PM MST (21Z) September 2, 2017 (source: https://nomads.ncdc.noaa.gov/thredds/catalog.html)

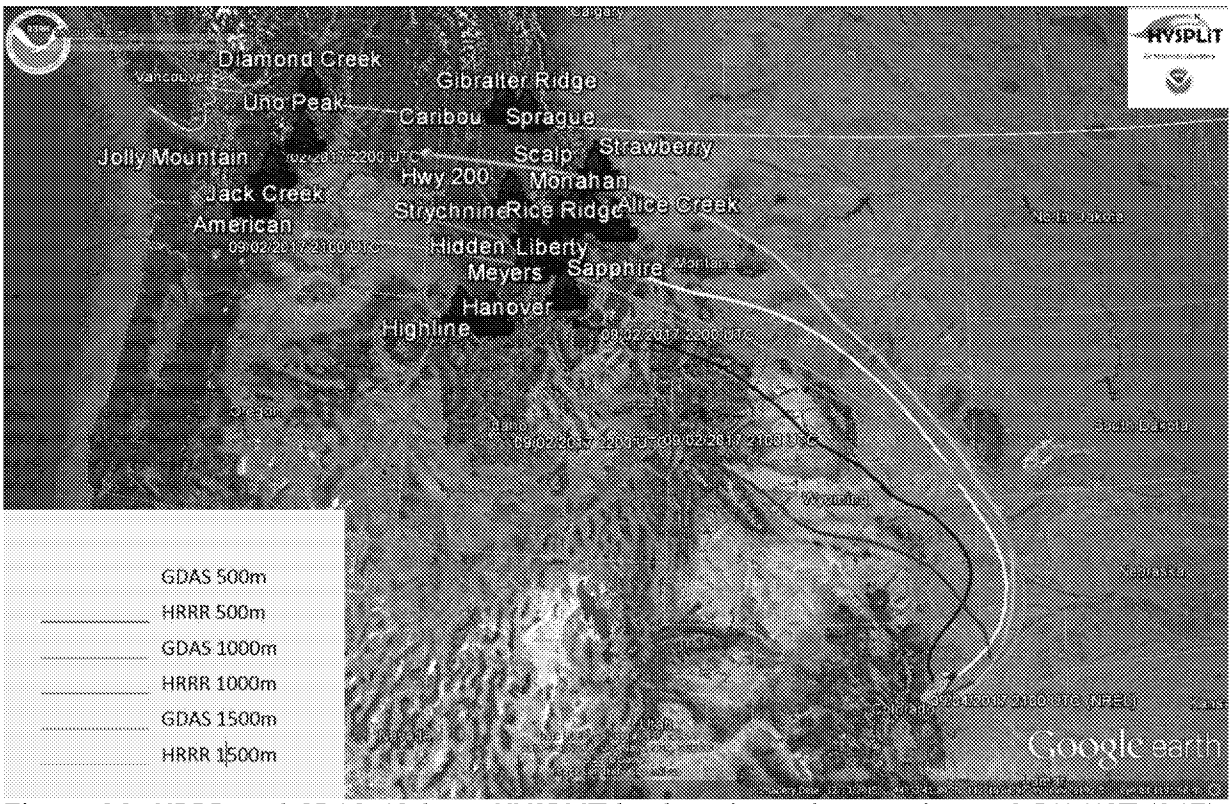


Figure 38: HRRR and GDAS 48-hour HYSPLIT back trajectories starting at 2 PM MST (21Z) September 2, 2017 and ending at 2 PM MST (21Z) September 4, 2017. (source: https://ready.arl.noaa.gov/HYSPLIT.php)

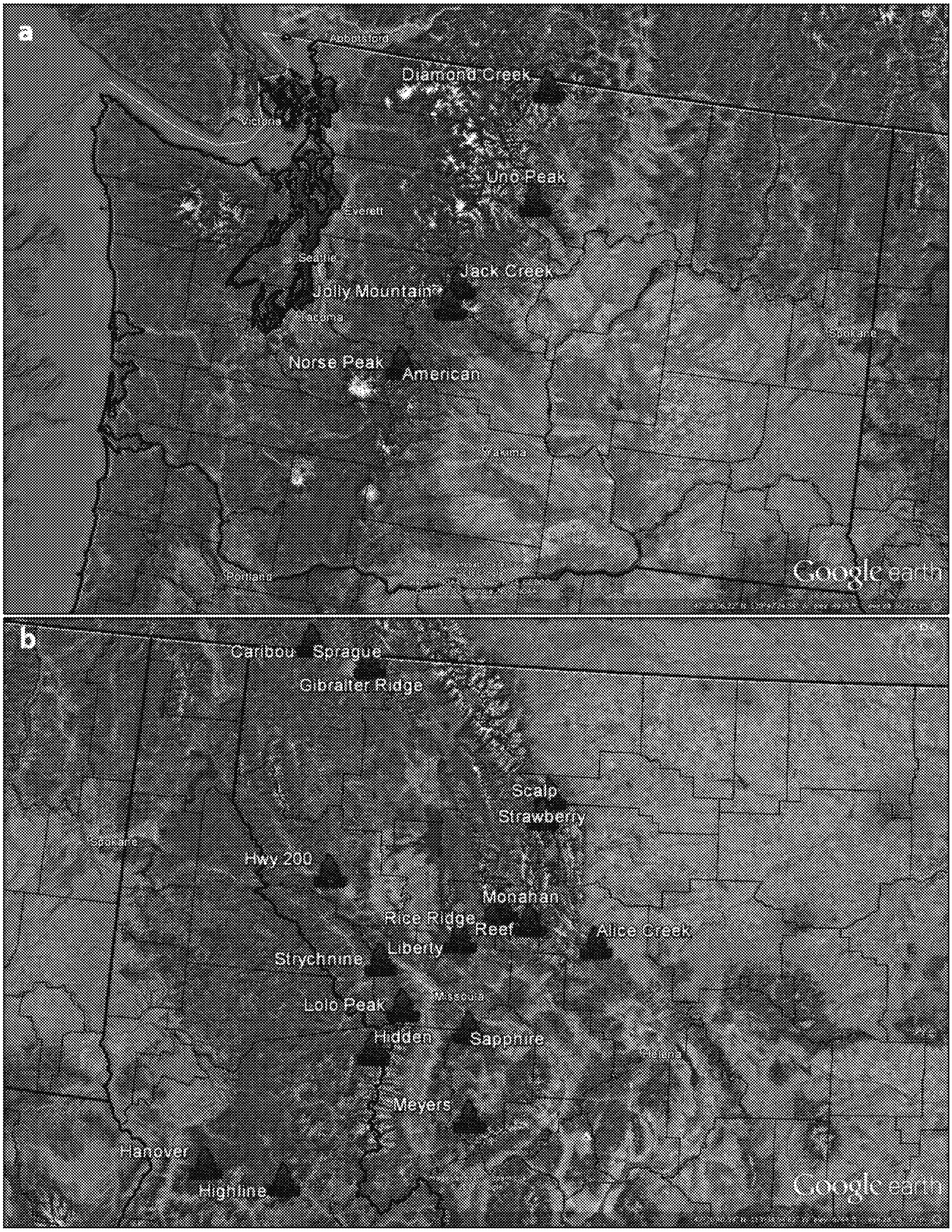


Figure 39a-b: Active wildfires on September 2, 2017 in (a) central Washington, and (b) northern Idaho and western Montana.

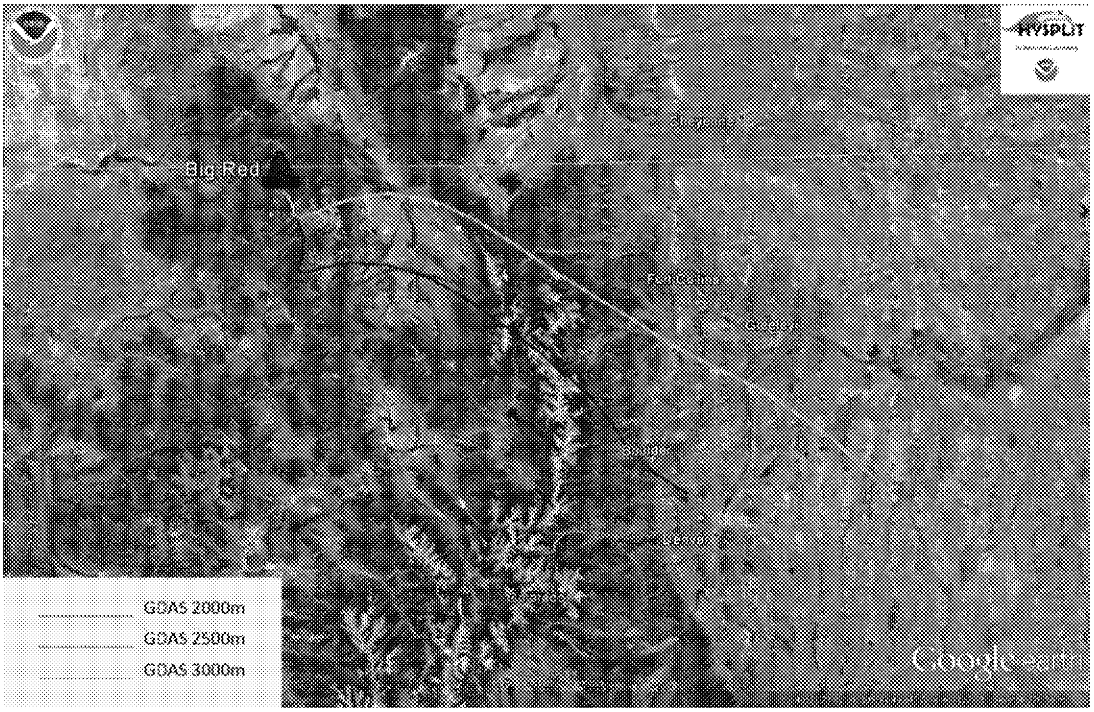


Figure 40: GDAS 18-hour HYSPLIT forward trajectories from the Big Red wildfire at 2000, 2500, and 3000 meters AGL, starting at 5:00 PM MST (0Z September 4, 2017) September 3, 2017 and ending at 11:00 AM MST (18Z) September 4, 2017. (source: https://ready.arl.noaa.gov/HYSPLIT.php)

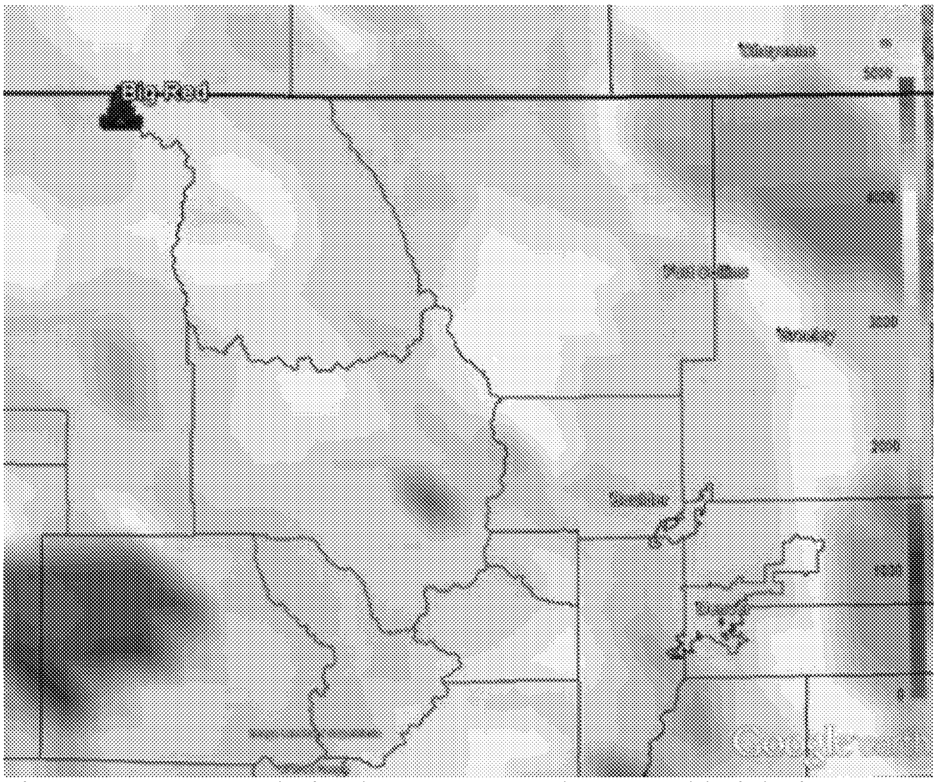


Figure 41: NAM Analysis Planetary Boundary Level height in meters AGL, 2 PM MST (21Z) September 3, 2017. (source: https://nomads.ncdc.noaa.gov/thredds/catalog.html)

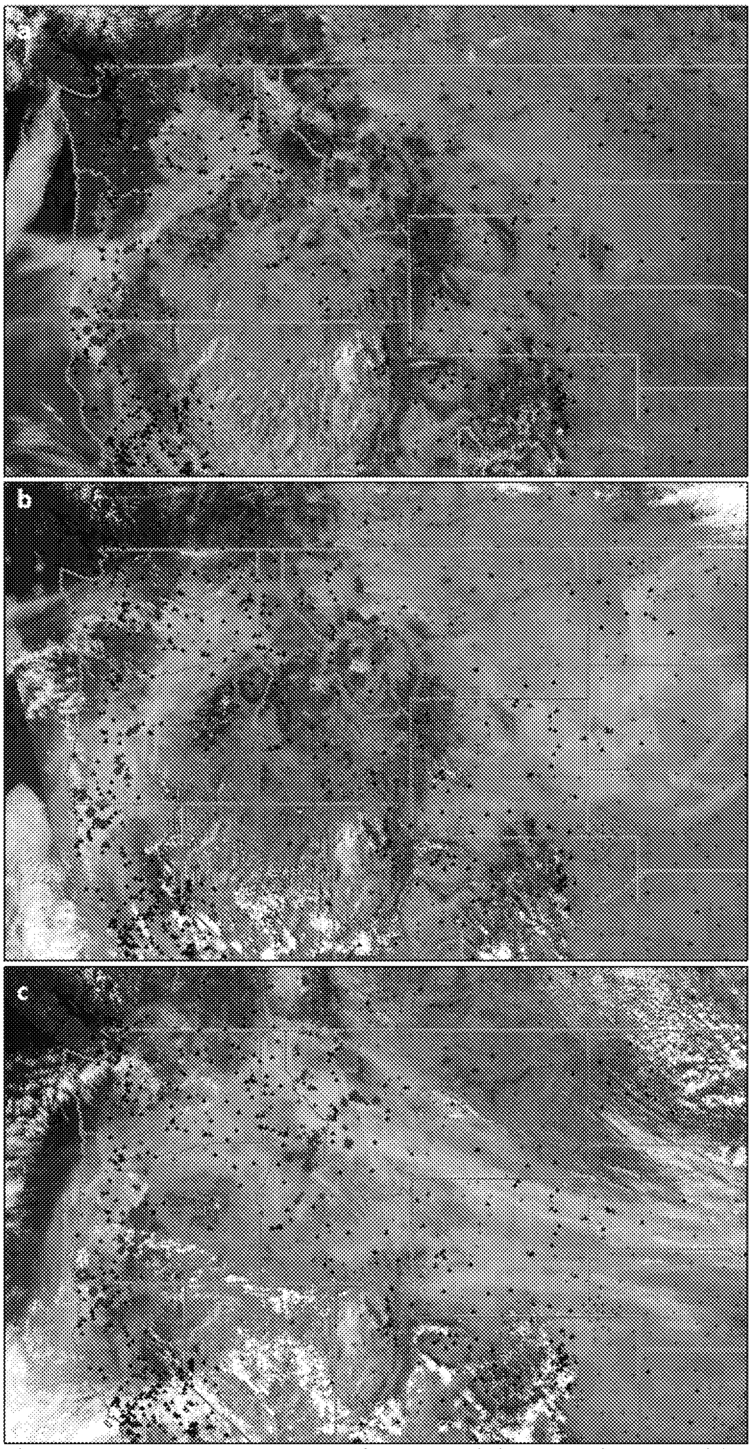


Figure 42a-c: MODIS Aqua image with HMS detected hot spots for (a) September 2, 2017 (combined image of two satellite passes with the western half of the image at approximately 2:32 PM MST (2132Z) and the eastern half of image at approximately 12:55 PM MST (1955Z)), (b) September 3, 2017 at approximately 1:37 PM MST (2037Z), and (c) September 4, 2017 (combined image of two satellite passes with the western half of the image at approximately 2:21 PM MST (2121Z) and the eastern half of image at approximately 12:42 PM MST (1942Z). (source: https://airnowtech.org)

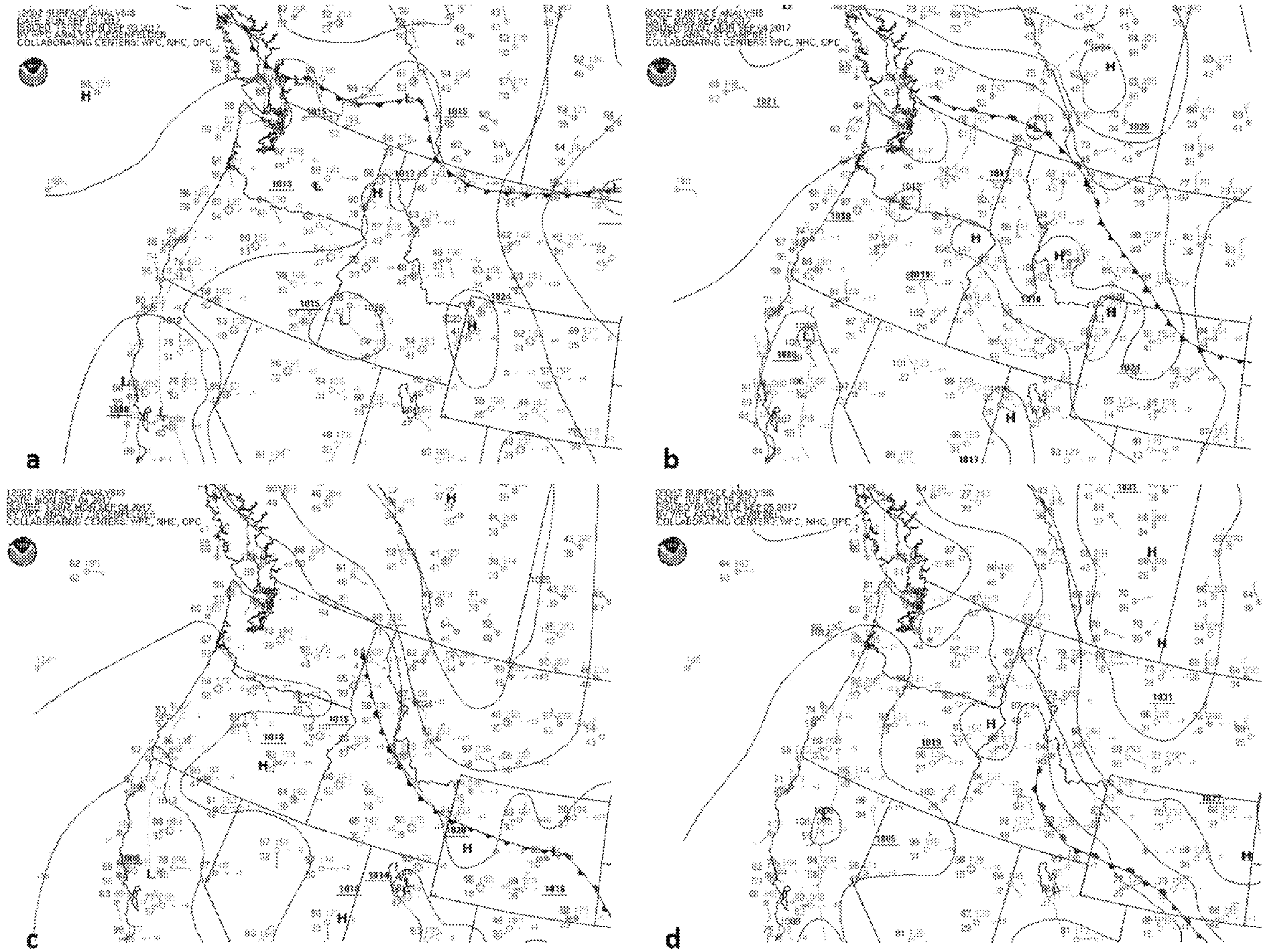


Figure 43a-d: NOAA surface analysis for northwestern US at (a) 5:00 AM MST (12z) on September 3, 2017, (b) 5:00 PM MST (0Z 9/4/2017) on September 3, 2017, (c) 5:00 AM MST (12Z) on September 4, 2017, and (d) 5:00 PM MST (0Z 9/5/2017) on September 4, 2017 (source: http://www.wpc.ncep.noaa.gov/)

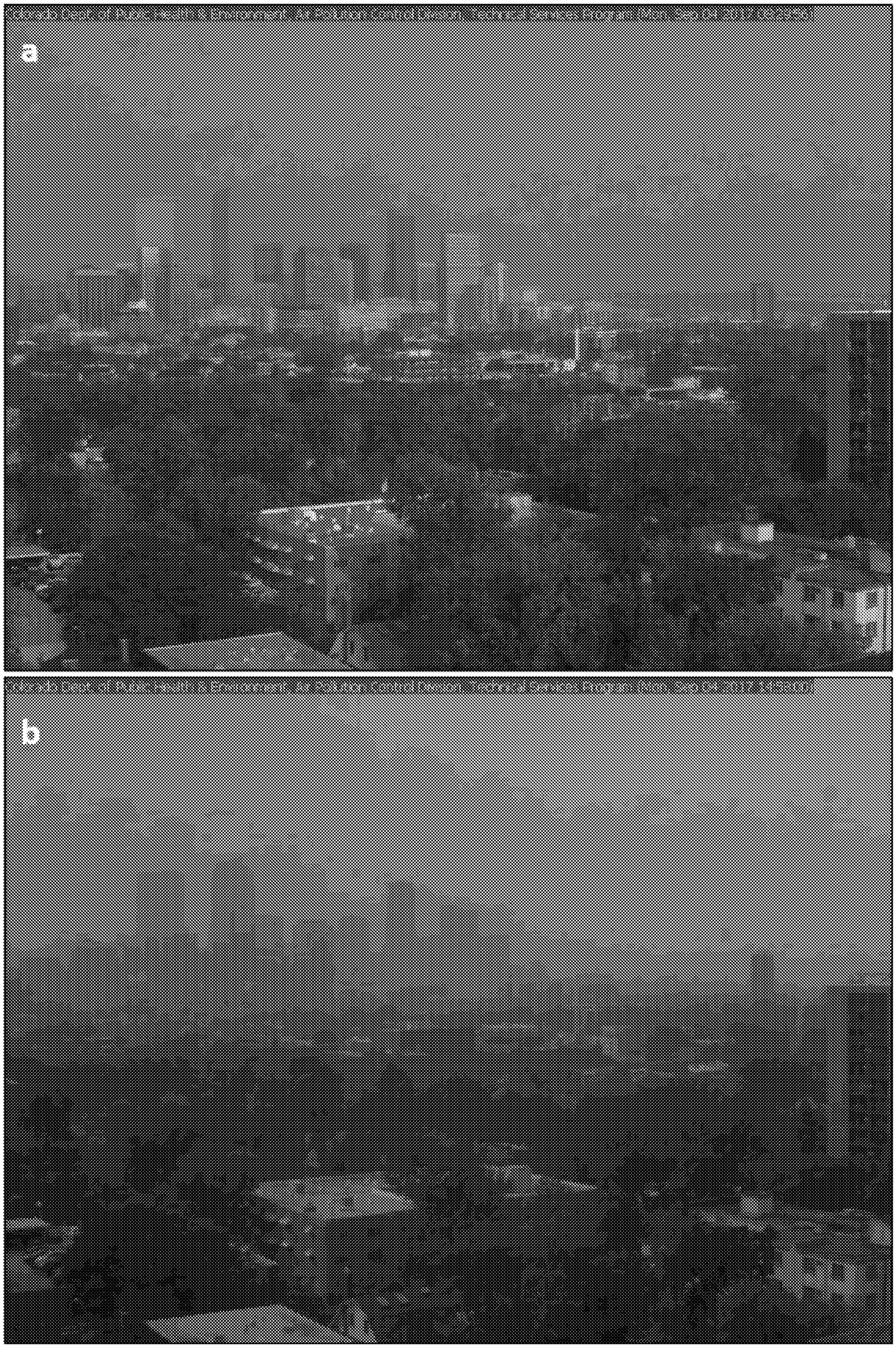


Figure 44a-b: Denver webcam image at (a) 8:29 AM MST and (b) 2:58 PM MST, on September 4, 2017. (source: https://www.colorado.gov/airquality/live_image.aspx)

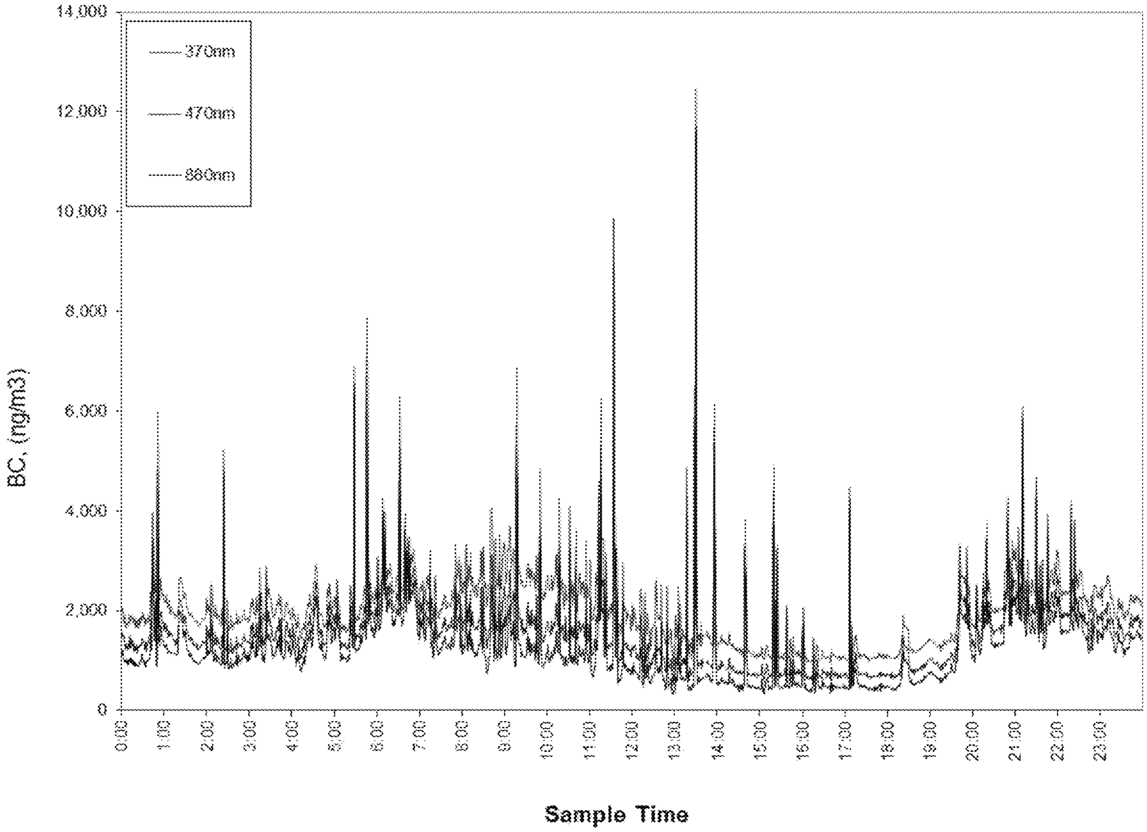


Figure 45: Black carbon absorption from APCD's near-road aethalometer measurement in central Denver on September 4, 2017.

The O_3 exceedance on September 4, 2017 across the DM/NFR area was due to a large wildfire outbreak in the Pacific Northwest and northern Rockies. Prolonged drought and higher than average temperatures set up dangerous wildfire conditions (Section 3.3), and that fire potential manifested. Forward and back trajectories for the September 4 event show contributions from 24 different wildfires. A cold front allowed concentrated smoke to push southeast into Colorado and ground-level smoke was visually observed and measured in the DM/NFR area. To quantify NO_x and VOCs emissions from these wildfires, forensic investigation into each of the 24 wildfires involved obtaining detailed information for estimating acres burned. Given the extreme number of fires and mega-fire status of many of the existing fires, emergency response resources were spread thin and consistent/reliable information on the multitude of wildfires was intermittent. Inciweb served as a primary resource for collecting this information (https://inciweb.nwcg.gov/). Where available, high-resolution maps with IR detection for fire parameters were used as the primary source for daily acres burned information. In cases where these maps were not available, agency reports, news releases, and social media were utilized to compile information. See Appendix B for details on each fire and resources used to estimate fire growth.

Trajectory analysis indicates emissions on September 2, 2017 from wildfires in Washington, Idaho, and Montana contributed to the air mass sampled in the DM/NFR area during the O_3 exceedance on September 4, 2017. Extremely dangerous fire weather was observed on September 2, 2017 in Washington and Idaho/Montana as presented in Figure 46a-c. Winds of 10-15 mph with relative humidity values in the 15-25% range were observed on the Idaho-Montana border midday into early evening on September 2 (Figure 46a-b). In central Washington, low humidity and high wind gusts began later afternoon and picked up with strong downslope winds in the Cascade Mountains increasing into the evening hours (Figure 46c). Ellensburg, WA, one of the closest weather observations to the central Washington fires and representative of a location impacted by the downslope winds, experienced a high temperature of 98˚F on September 2, 2017 (the normal high is 79˚F), with a minimum relative humidity of 16%, and a maximum wind speed of 19 mph. Missoula, MT the central-most weather station to the Idaho/Montana fires, experienced a record high temperature of 97˚F, a minimum relative humidity of 7%, with maximum wind speed of 28 mph on September 2, 2017. Collectively, these conditions made for extremely volatile fire weather with new fires developing and growth from preexisting fires inevitable.

Using the same methodology detailed in the September 2, 2017 exceedance (Section 4.2.1), NO_x and VOCs emissions (Q) and emissions weighted distance (D) for the exceedance on September 4 was quantified. Table 12 contains information for determining overall Q/D for the September 4, 2017 O_3 exceedance. Aggregating 24 fires in the source regions affecting Denver's O_3 resulted in a Q/D of 104.3, achieving the Q/D greater than 100 threshold suggested by EPA's Guidance.

Technical analysis of the clear causal relationship between wildfire smoke and O_3 exceedance in the DM/NFR area on September 4, 2017 has been demonstrated by examining the meteorological conditions, transport winds and trajectories, wildfire locations and emissions, as well as additional evidence of smoke at the effected monitors using satellite and ground observations. As a result, this demonstration provides sufficient evidence that these wildfire emissions were transported to the monitors and the wildfires influenced the monitored concentrations, as well as quantification of the wildfire's emissions that contributed to the monitored O_3 exceedance on September 4, 2017.

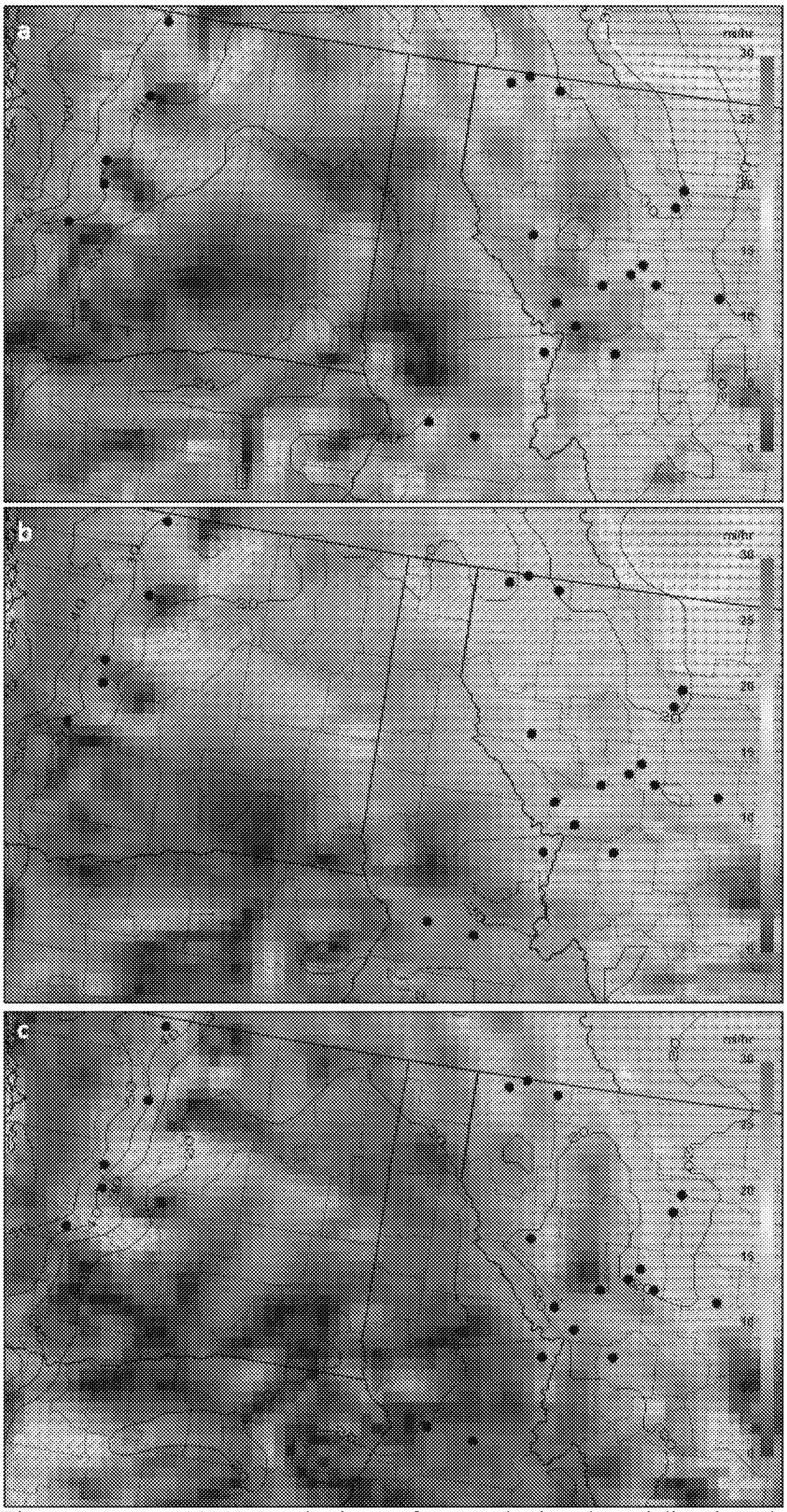


Figure 46a-c: NAM Analysis surface relative humidity isopleths, wind vectors, and wind speed color contours with fire locations (black dots) at (a) 2:00 PM MST (21Z) September 2, 2017, (b) 5:00 PM MST (00Z September 3, 2017) September 2, 2017, and (c) 8:00 PM MST (03Z September 3, 2017) September 2, 2017.

Table 12: Wildfire information for fires affecting September 4, 2017 O_3 exceedances.

Fire	Lat	Long	Cause	Burned on	Acres Burned	NOx (tpd)	VOCs (tpd)	Distance (km)	Q (tpd)	Q/D (tpd/km)
Big Red	40.925	-106.884	*lightning*	9/3/17	695	30.9	664.0	195.4	694.9	3.6
Meyers	45.995	-113.580	*lightning*	9/2/17	7163	303.4	6483.6	974.71	6787.1	7.0
Alice Creek	47.154	-112.502	*lightning*	9/2/17	4153	330.2	7202.4	1013.23	7532.7	7.4
Strychnine	46.956	-116.627	*unknown*	9/2/17	800	72.5	1889.3	1013.23	1961.8	1.9
Sapphire Complex	46.563	-113.634	*lightning*	9/2/17	130	5.1	89.1	1021.35	94.2	0.1
Highline / Goat	45.494	-115.233	*lightning*	9/2/17	6649	528.7	11531.2	1040.67	12059.9	11.6
Monahan	47.273	-113.138	*lightning*	9/2/17	231	19.0	508.4	1053.85	527.3	0.5
Hidden	46.381	-114.509	*lightning*	9/2/17	606	48.2	1051.0	1056.67	1099.2	1.0
LoLo Peak	46.674	-114.268	*lightning*	9/2/17	2325	184.9	4032.2	1064.76	4217.1	4.0
Rice Ridge	47.268	-113.485	*lightning*	9/2/17	12730	1012.3	22077.3	1070.59	23089.5	21.6
Reef	47.348	-113.402	*lightning*	9/2/17	1186	97.4	2610.0	1073.15	2707.4	2.5
Liberty	47.139	-113.780	*lightning*	9/2/17	1197	46.8	820.4	1075.07	867.2	0.8
Hanover	45.548	-115.967	*lightning*	9/2/17	1248	99.2	2164.4	1091.73	2263.6	2.1
Strawberry	48.089	-113.015	*lightning*	9/2/17	116	9.5	255.3	1119.08	264.8	0.2
Hwy 200	47.495	-115.060	*lightning*	9/2/17	8807	700.3	15273.7	1171.07	15974.0	13.6
Scalp	47.957	-113.071	*lightning*	9/2/17	1589	130.5	3496.9	1199.98	3627.4	3.0
Sprague	48.607	-113.829	*lightning*	9/2/17	1717	136.5	2977.7	1201.41	3114.3	2.6
Gibralter Ridge	48.857	-114.857	*lightning*	9/2/17	128	10.2	222.0	1270.78	232.2	0.2
Caribou	48.973	-115.441	*lightning*	9/2/17	6890	547.9	11949.1	1308.76	12497.0	9.5
Uno Peak	48.117	-120.377	*unknown*	9/2/17	1300	106.7	2860.9	1527.83	2967.6	1.9
Jolly Mountain	47.377	-121.019	*lightning*	9/2/17	3522	319.9	10697.9	1528.38	11017.8	7.2
Norse Peak / American	46.951	-121.374	*lightning*	9/2/17	977	82.9	2342.2	1530.95	2425.2	1.6
Jack Creek	47.514	-120.959	*lightning*	9/2/17	646	54.8	1548.7	1531.6	1603.5	1.0
Diamond Creek	48.855	-120.414	*human*	9/2/17	9042	353.2	6197.7	1576.87	6550.9	4.2
				SUM	73847	5231.0	118945.4		124176.4	109.2
					Emisions Weighted Distance (km)				1190.83	
					Q/Emisisons Weighted Distance				**104.3**	

4.2.3 Historical Fluctuations of O_3 Concentrations in the DM/NFR area

A historical comparison of event related O_3 concentrations with similar seasonal non-event related high O_3 concentrations is required to satisfy key factor #2 in a Tier 2 demonstration, as described in the Guidance. This factor is addressed by demonstrating that the exceedance is either 1) in the 99th percentile of the 5-year distribution of O_3 monitoring data, or 2) one of the four highest O_3 concentrations within one year. A comparison of O_3 monitoring data for sites affected by the September 2 and 4, 2017 wildfire smoke event was made using valid quality assured hourly and daily maximum 8-hour average data values from the Aspen Park, Chatfield, Highland, NREL, Rocky Flats North, and Welch sites from 2011 through 2016. APCD has been monitoring O_3 concentrations at these sites prior to 2011. However, a six year time period was selected for this analysis to keep the statistical comparisons to a time frame that is as representative as possible for the comparison to current climate conditions and emission inventories while still attaining a statistically relevant sample.

Of the sites listed in this evaluation the most important is NREL because its maximum daily 8-hour average O_3 concentrations exceeded the 2008 0.075 ppm O_3 standard and will affect design values in Colorado's NAAQS non-attainment reclassification from "moderate" to "serious" under the 2008 O_3 standard. The other sites reported in this evaluation were selected because they exceeded the 2015 0.070 ppm standard and may contribute to future non-attainment designations under the 2015 O_3 standard. These additional sites were also included to show the geographical extent of the event area.

Historical Comparison of Monthly Values

Historical non-event max daily 8-hour average O_3 data used in this evaluation begin on January 1, 2011 and end on December 31, 2016. The exception to this is data from the Highlands site where construction at the site prohibited the collection of O_3 data from October 2013 through August 2015. Historical evaluations of the Highland data are made with a smaller sample size than other sites. Descriptive statistics for the historical data is presented in Table 13, all data values are presented in ppm.

Table 13: Summary of September Non-Event Max Daily 8-hour Average O_3 Data (2011-2016)

(Summary of Maximum Daily 8-hour Average O_3 for September 2011-2016)

Evaluation	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**		**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**
Mean	0.047	0.051	0.049	0.051	0.052	0.046
Median	0.047	0.051	0.050	0.051	0.052	0.047
Mode	0.048	0.056	0.052	0.056	0.046	0.046
St. Dev.	0.008	0.010	0.009	0.010	0.011	0.010
Minimum	0.023	0.017	0.020	0.016	0.018	0.014
99 %ile	0.066	0.071	0.070	0.071	0.078	0.069
Maximum	0.068	0.081	0.073	0.072	0.079	0.071
Range	0.045	0.064	0.053	0.0561	0.061	0.057
Count	172	179	146	177	176	176

Table 14 shows the max daily 8-hour average O_3 concentrations for the September 2 & 4, 2017 events as a percentile of six years of historical data from 2011 to 2016 for the month of September. All sites exceeded the 99th percentile threshold except RFN, which reported 96.5 and 98.8 percentiles for the September 2 & 4 events, respectively. Maximum values were observed at Aspen Park, NREL and Welch sites. The RFN site did not attain the Tier 2 percentile threshold of 99% as described above.

Table 14: September 2 and 4, 2017 Event Percentiles of Max Daily 8-hour Average O_3 for September 2011 to 2016 Data

Event Percentiles for Monthly September Data						
Evaluation	Aspen Park 08-059-0013	Chatfield 08-035-0004	Highland 08-005-0002	NREL 08-059-0011	RFN 08-059-0006	Welch 08-059-0005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**	**0.073 ppm**	**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**
9/2/2017		99.0 %ile		Max Value	96.5 %ile	Max Value
9/4/2017	Max Value	99.4 %ile	99.1 %ile	Max Value	98.8 %ile	Max Value

Figures 47, 48, and 49 are monthly non-event historical comparison plots that show the historical seasonal variability for the max daily 8-hour average O_3 concentrations for complete calendar years 2011 to 2016. The graphs are time series that show the 5th, 50th and 99th percentile of the historical data for each month of the year. Maximum concentrations are shown as purple dashes above the 99th percentile line. The maximum daily 8-hour O_3 concentrations for each event day are plotted on each graph as either a black "X" and/or a green triangle. This allows for a graphical representation of the comparison between event concentrations and historical seasonal concentrations. The horizontal dashed red lines represent the 2008 0.075 ppm and the 2015 0.070 ppm O_3 standard levels.

Historical Comparison of 2-Week Window Values

Historical non-event max daily 8-hour average O_3 data used in this evaluation begin on August 26 and end on September 9 for years 2011 to 2016 (a week before and after the September 2 and September 4 events). The exception to this is Highlands data where construction at the site prohibited the collection of O_3 data from October 2013 through August 2015. Historical evaluations of the Highland data are made with a smaller sample size than others sites. The descriptive statistics for this historical data is presented in Table 15, all data values are presented in ppm.

Table 15: Summary of 2-Week Non-Event Max Daily 8-hr Average O_3 Data (August 26 to September 9, 2011-2016)

Comparison of Event Data 2-Week Non-Event Historical Summary Data						
Evaluation	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**		**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**
Mean	0.051	0.056	0.057	0.056	0.057	0.052
Median	0.050	0.055	0.059	0.058	0.058	0.053
Mode	0.050	0.063	0.059	0.059	0.064	0.049
St. Dev.	0.009	0.011	0.009	0.010	0.010	0.010
Minimum	0.032	0.030	0.041	0.029	0.030	0.026
95 %tile	0.067	0.074	0.074	0.072	0.071	0.070
99 %tile	0.073	0.082	0.080	0.076	0.078	0.074
Maximum	0.080	0.086	0.085	0.084	0.079	0.080
Range	0.048	0.056	0.044	0.055	0.049	0.054
Count	81	87	68	90	86	89

Table 16 shows the maximum daily 8-hour average O_3 concentrations for the September 2 and 4, 2017 events as a percentile of six years of historical data from 2011 to 2016 (August 26 to September 9). Two sites, NREL and Welch, met or exceeded the 99th percentile threshold for both the September 2 and 4, 2017 events. No maximum values were observed at any of the sites.

Table 16: September 2 & 4, 2017 Event Percentiles for Max Daily 8hr Average O_3 for August 26 to September 9, 2001 to 2016 Data

Event Percentiles for 2-Week Data Window						
Evaluation	Aspen Park 08-059-0013	Chatfield 08-035-0004	Highland 08-005-0002	NREL 08-059-0011	RFN 08-059-0006	Welch 08-059-0005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**	**0.073 ppm**	**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**
9/2/2017		90.8 %ile		99.0 %ile	94.1 %ile	99.1 %ile
9/4/2017	98.8 %ile	94.2 %ile	91.0 %ile	99.0 %ile	97.6 %ile	99.0 %ile

Figures 50, 51, and 52 are 2-week non-event historical comparison plots that show the variability of the maximum daily 8-hour O_3 concentrations for the sites of interest for the time period August 26 to September 9 for years 2011 to 2016. The graphs show the maximum daily 8-hour average O_3 by date for each year. The dashed line represents the 99th percentile of all data displayed on the plot. The maximum daily 8-hour O_3 concentrations for each event day are plotted on each graph as either a blue or red circle. This allows for a graphical representation of the comparison between event concentrations and historical seasonal concentrations.

Historical Comparison of Hourly Diurnal Values

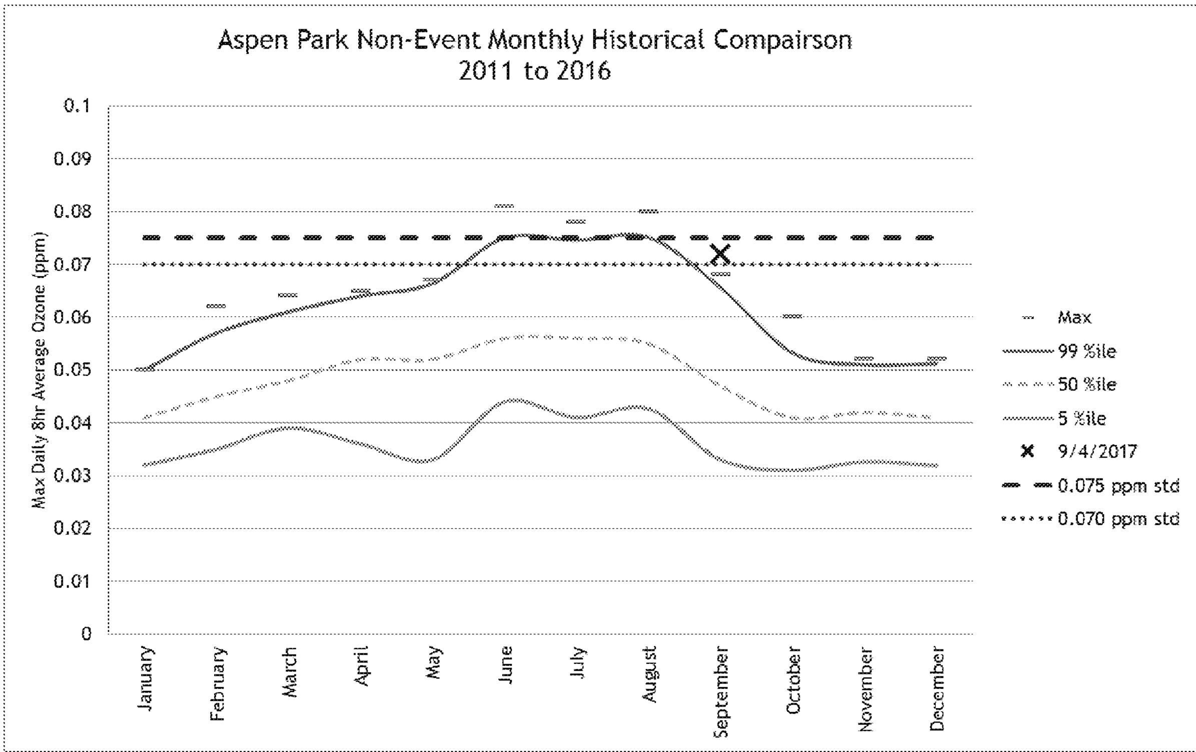
Figure 53, 54, and 55 are graphs of diurnal deviation from normal comparisons. These show the historical diurnal variability for hourly averaged data for the sites of interest for a two week time interval from August 26 to September 9 (a week before and after the 9/2 and 9/4 events) for a five-year time period from 2013 to 2017. The graphs are hourly time series box and whisker plots for daily 24 hour periods. The box and whisker plots graphically represent the overall distribution of each data set including the mean (◇), the inner quartile range (IQR, defined to be the distance between the 75th% and 25th%), the median (represented by the horizontal black line), and maxima and minima (vertical wiskers). The green dots and blue dots represent the the hourly average concentrations at the corresponding site for the September 2 and 4, 2017 events, respectively. These graphs show the diurnal evolution of O_3 concentrations for each site and each event, relative to historical values. The majority of the event values, leading up to the peak concentrations, are above the 75th percentile. The September 2, 2017 event resulted in historical maximum hourly values at Highland (hours 19 to 21), NREL(hours 16 and 17), RFN(hour 8), and Welch (hour 17). The 9/4/17 event resulted in historical maximum hourly values at Aspen Park (hours 5,6,14,15,16, and 19), Chatfield (hour 14), Highland (hours 5,6, and 7), NREL (hours 9 and 13), RFN (hours 5,6,7,12,13, and 14) and Welch (hours 4,5,6,7,13, and 15).

Tier 2 Alternate Test

The alternate Tier 2 test evaluates if the observed event maximum daily 8-hour average concentration(s) are in the top four values observed within one year of data. Rank ordered maximum daily 8-hour average O_3 concentrations for all sites of interest are listed in Table 17, for data from September 4, 2016 to September 4, 2017. In the rank order method, if the ranking value had 1 or more equal ranking values, then all equal ranking values received the same ranking. Equal ranking values higher in the ranking order were assigned their ordinal ranking value. The September 2, 2017 event resulted in NREL(4) and Welch(1) having rank order values in the top four. The September 4, 2017 event resulted in Aspen Park(1), NREL(4), and RFN (1) having rank order values in the top four. These sites have ranking values that meet the secondary key factor #2 threshold.

Table 17: September 2 & 4, 2017 Event Rank Values for Max Daily 8hr Average values for September 4, 2016 to September 4, 2017

(September 2 & 4, 2017 Rank Value of Maximum Daily 8hr Average O3 for September 4, 2016 to September 4, 2017 data)						
Evaluation	Aspen Park 080590013	Chatfield 080350004	Highland 080050002	NREL 080590011	RFN 080590006	Welch 080590005
9/2/2017		**0.071 ppm**		**0.076 ppm**	**0.071 ppm**	**0.075 ppm**
9/4/2017	**0.072 ppm**	**0.073 ppm**	**0.071 ppm**	**0.076 ppm**	**0.078 ppm**	**0.074 ppm**
9/2/2017		10		4	15	1
9/4/2017	1	7	5	4	1	5



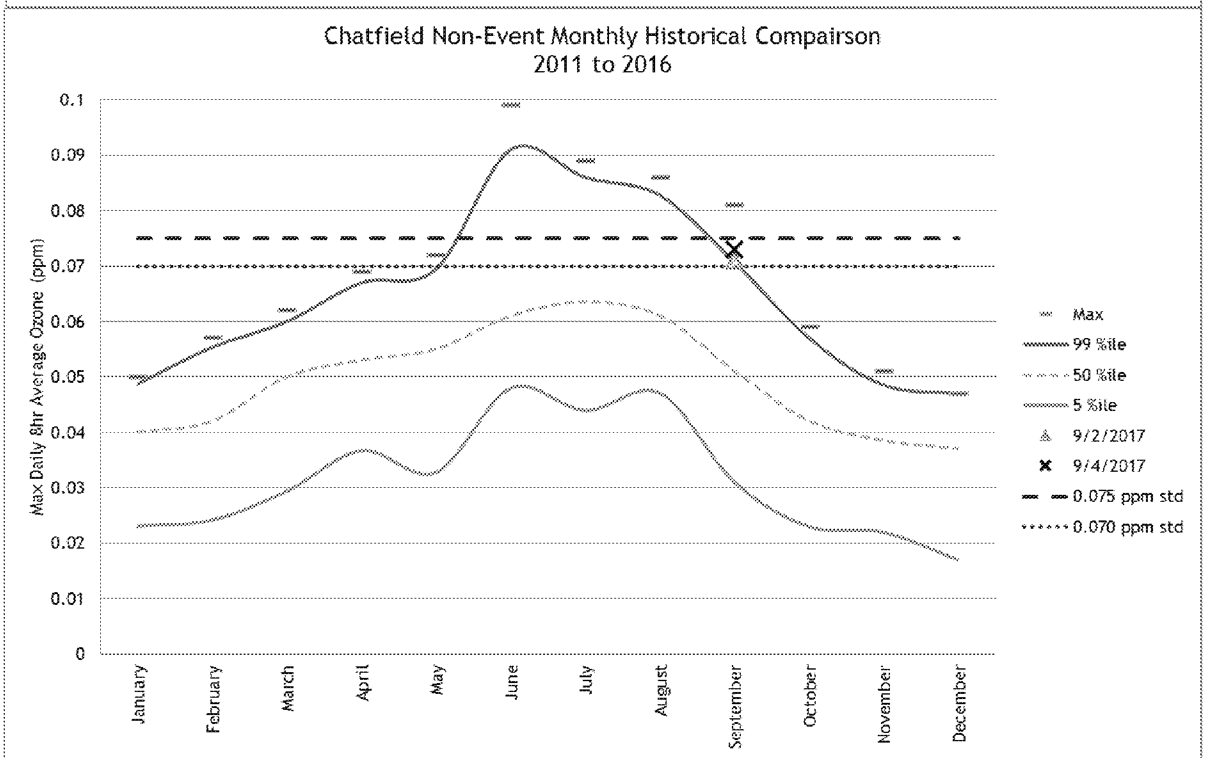


Figure 47: Monthly Non-Event Historical Comparison Plots for Aspen Park (AQS ID 080590013) and Chatfield (AQS ID 080350004)

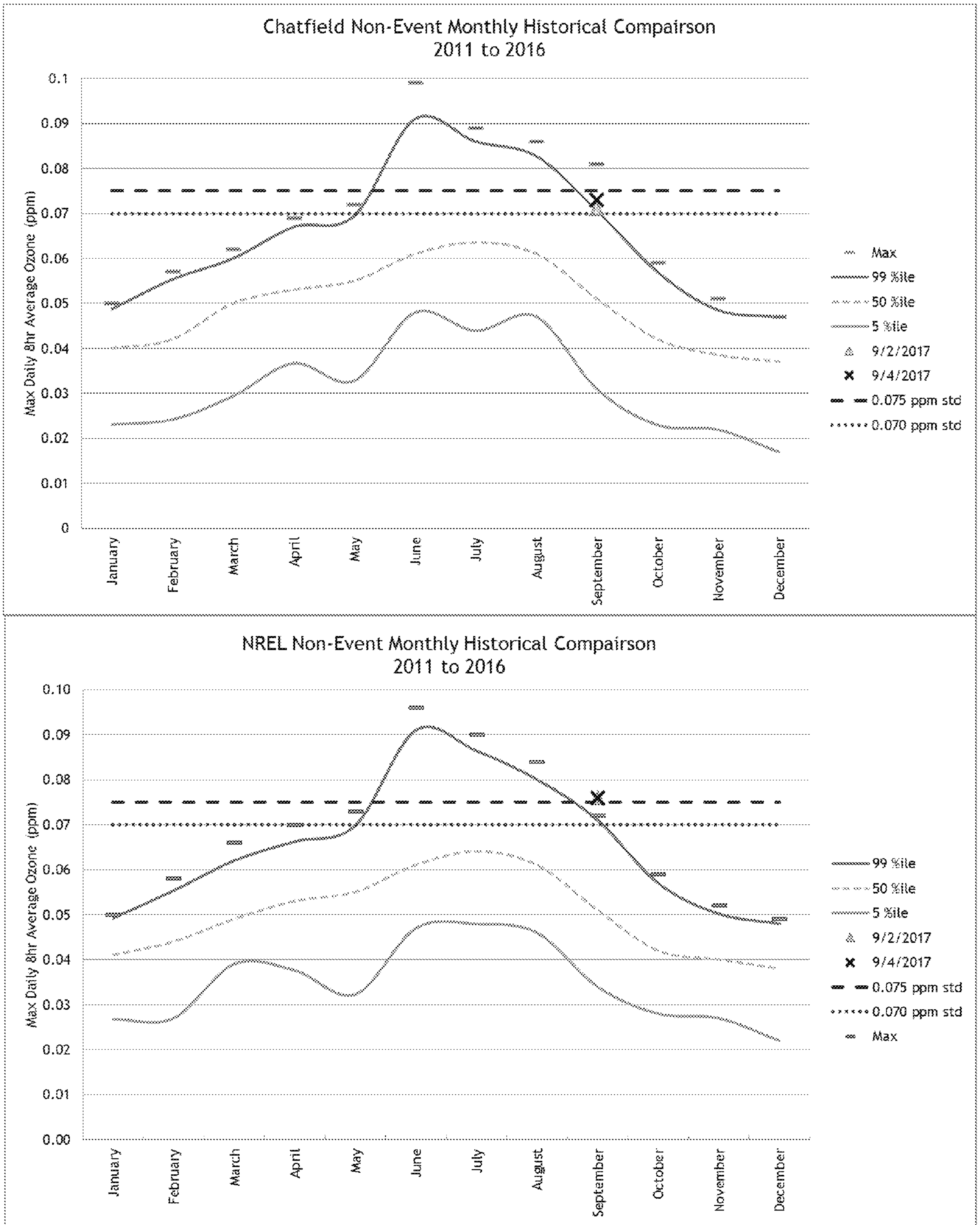
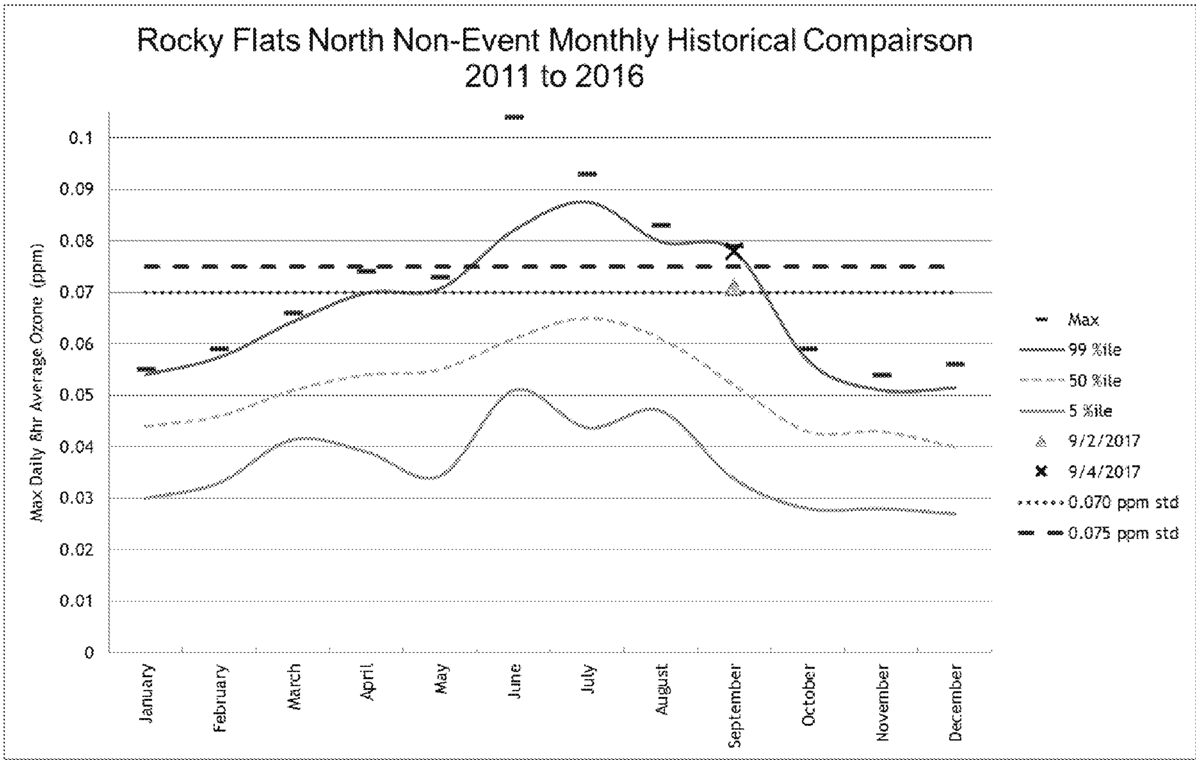


Figure 48: Monthly Non-Event Historical Comparison Plots for Highland (AQS ID080050002) and NREL (AQS ID 080590011)



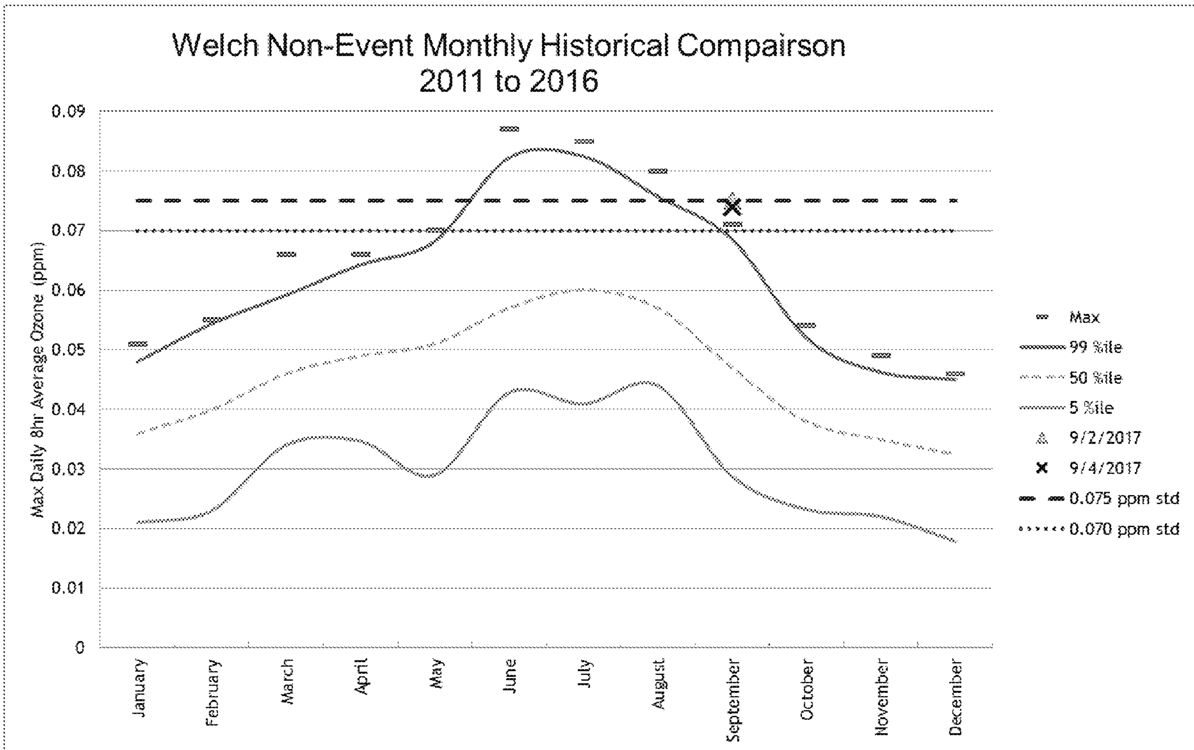


Figure 49: Monthly Non-Event Historical Comparison Plots for RFN (AQS ID 080590006) and Welch (AQS ID080590005)

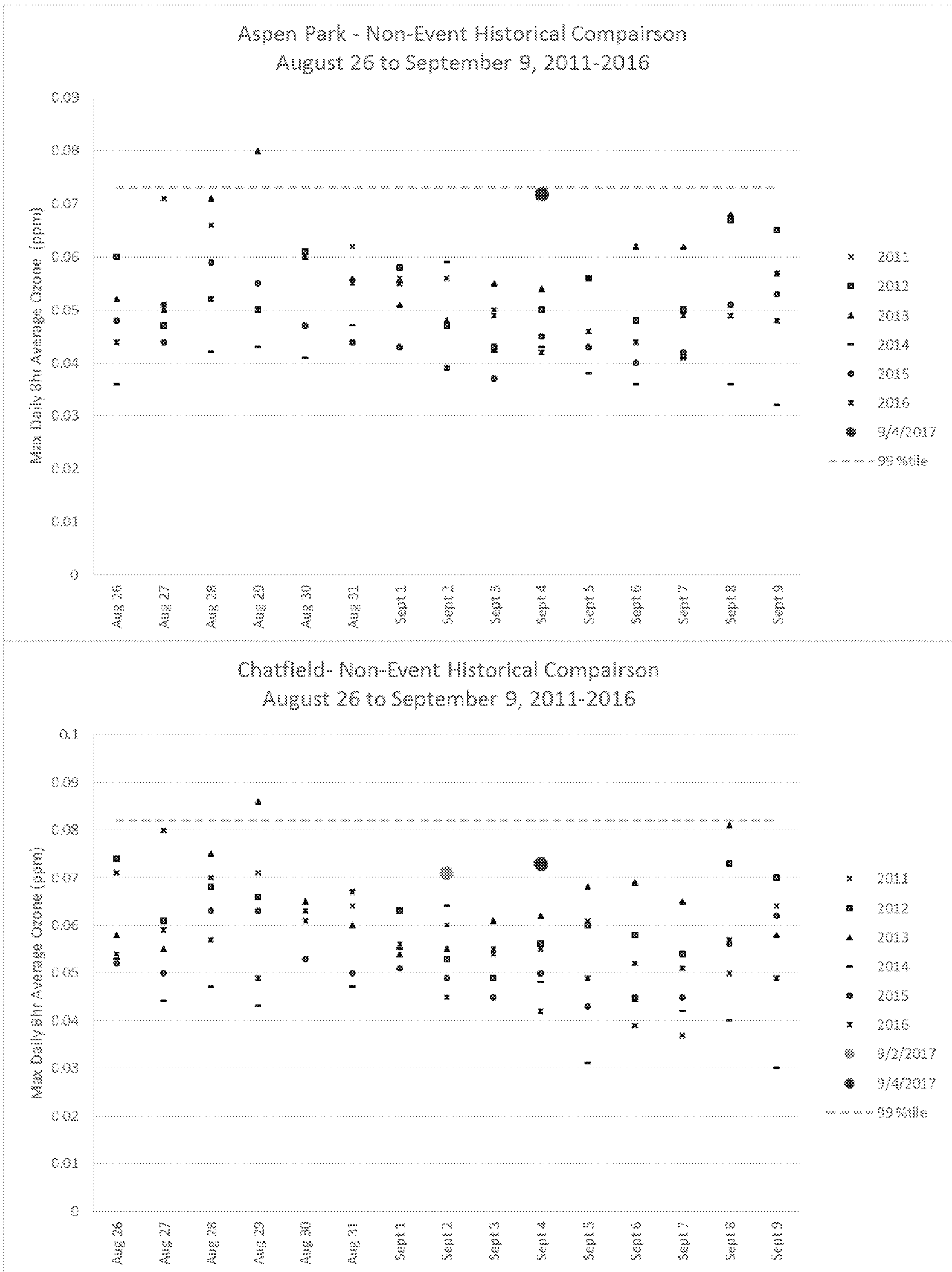


Figure 50: 2-Week Non-Event Historical Comparison Plots for Aspen Park (AQS ID 080590013) and Chatfield (AQS ID 080350004)

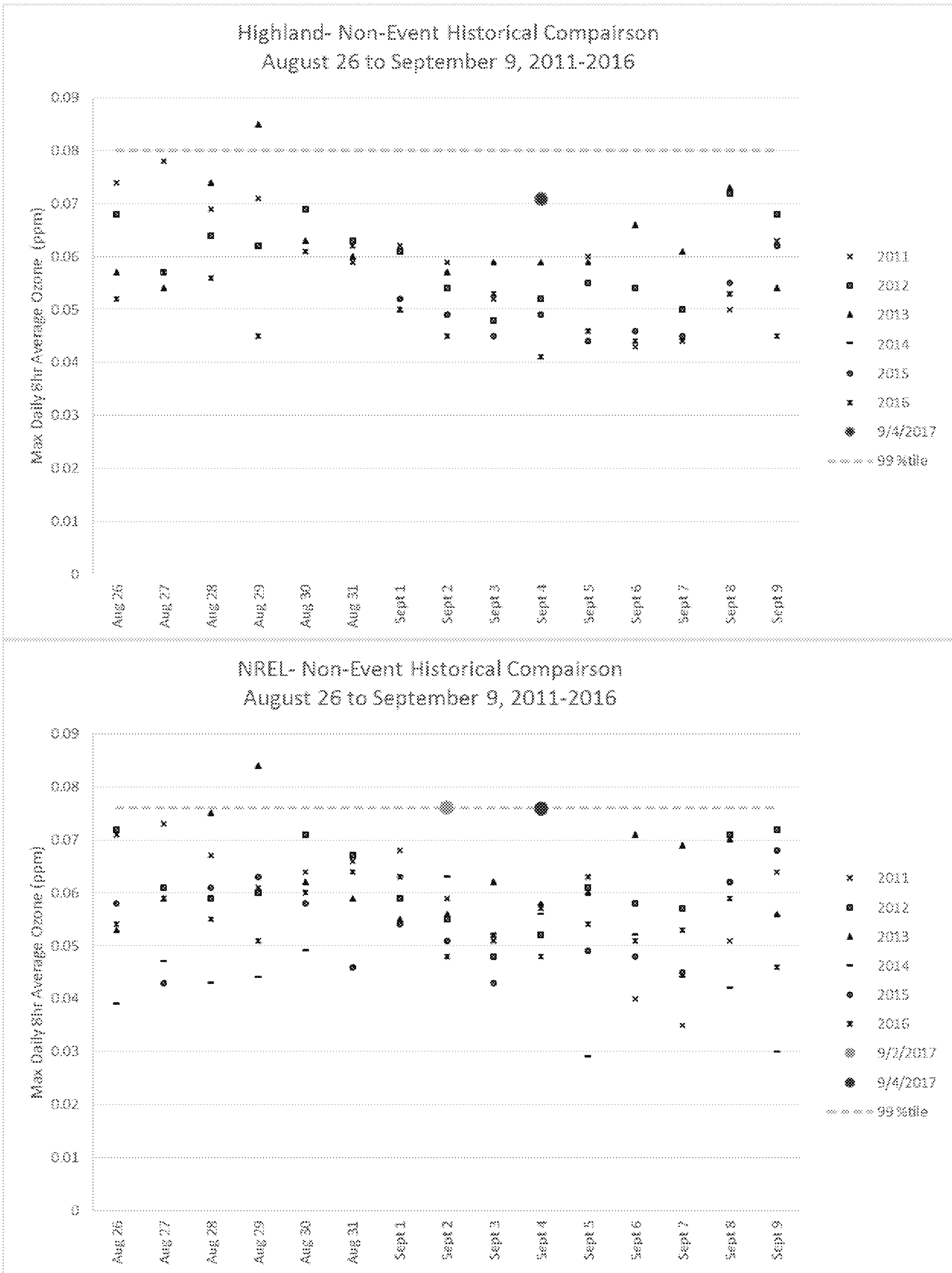


Figure 51: 2-Week Non-Event Historical Comparison Plots for Highland (AQS ID 080050002) and NREL (AQS ID 080590011)

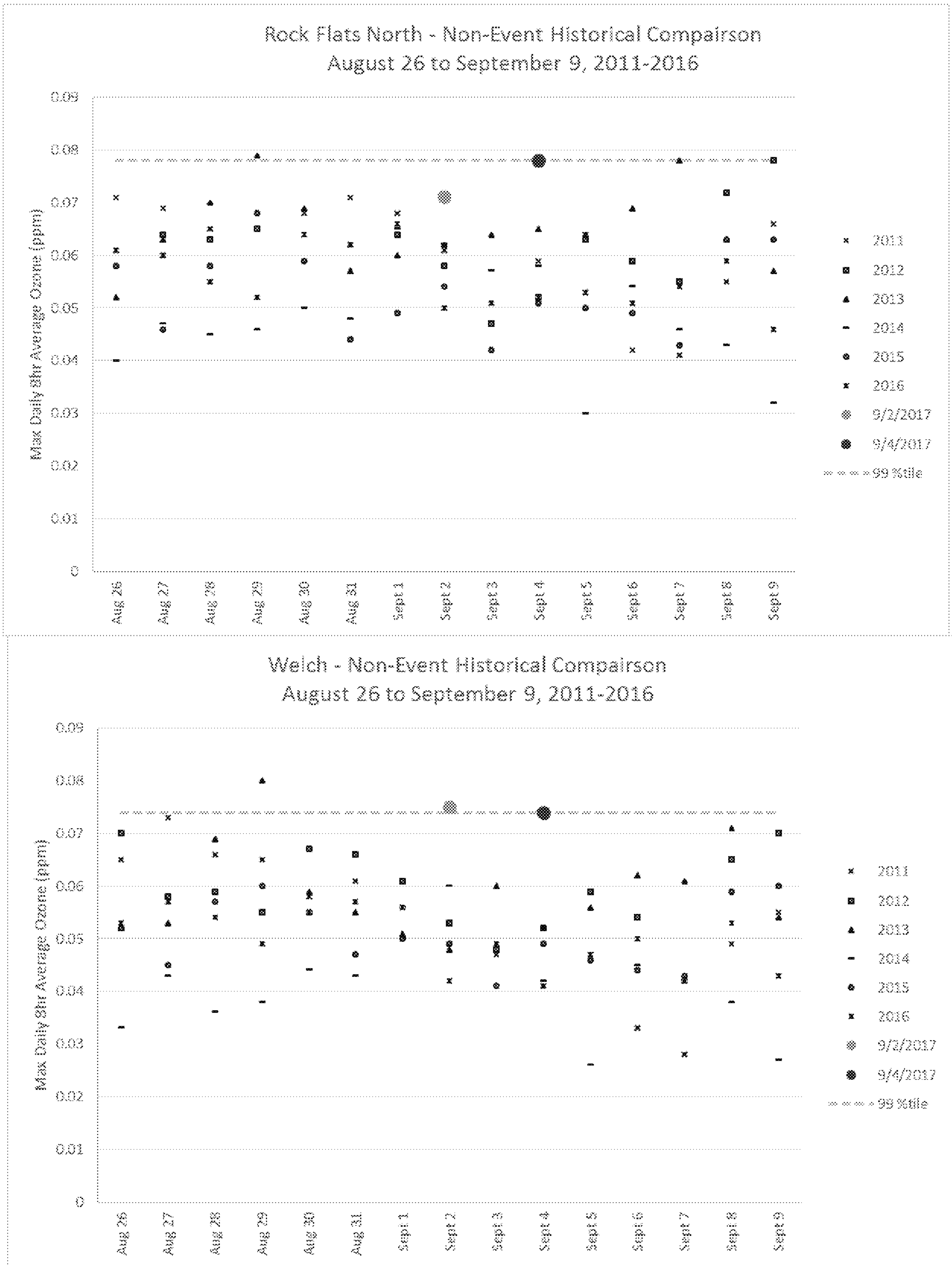
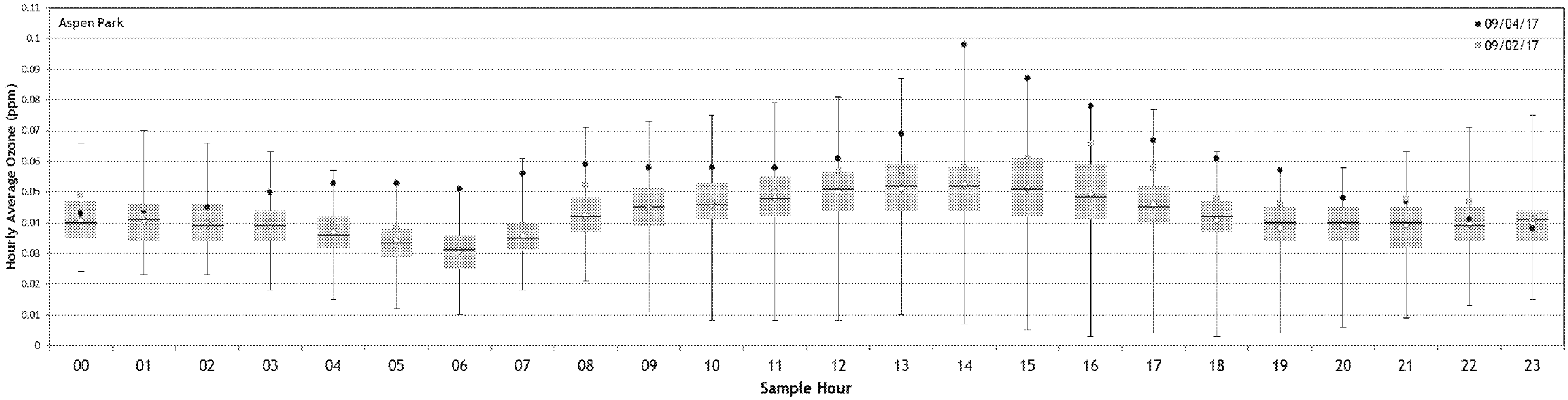


Figure 52: 2-Week Non-Event Historical Comparison Plots for RFN (AQS ID 080590006) and Welch (AQS ID 080590005)



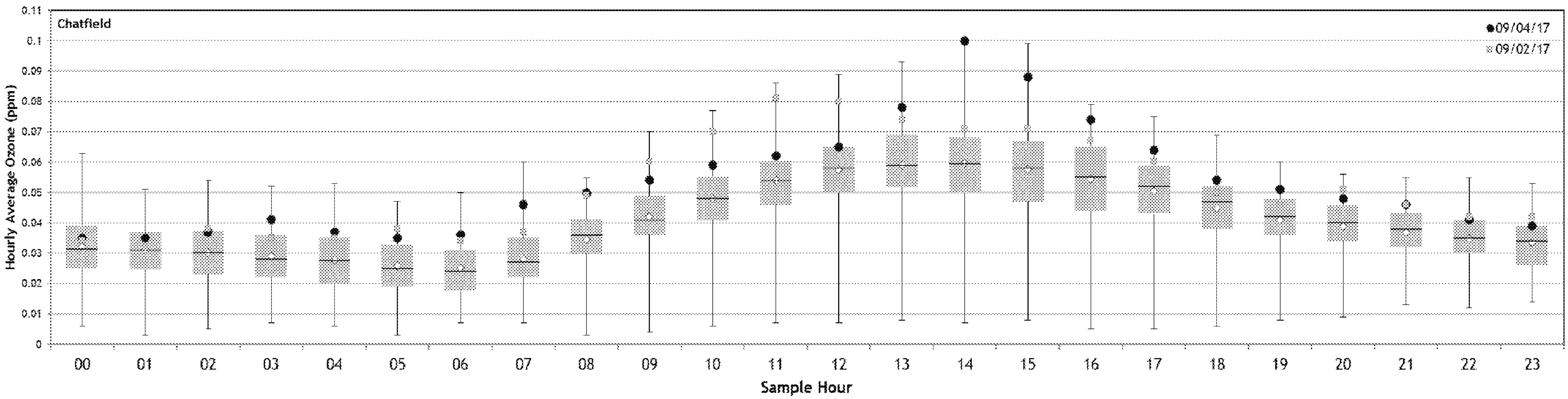


Figure 53: Diurnal Deviation from Normal Plots for hourly data at Aspen Park (AQS ID 080590013) and Chatfield (AQS ID 080350004)

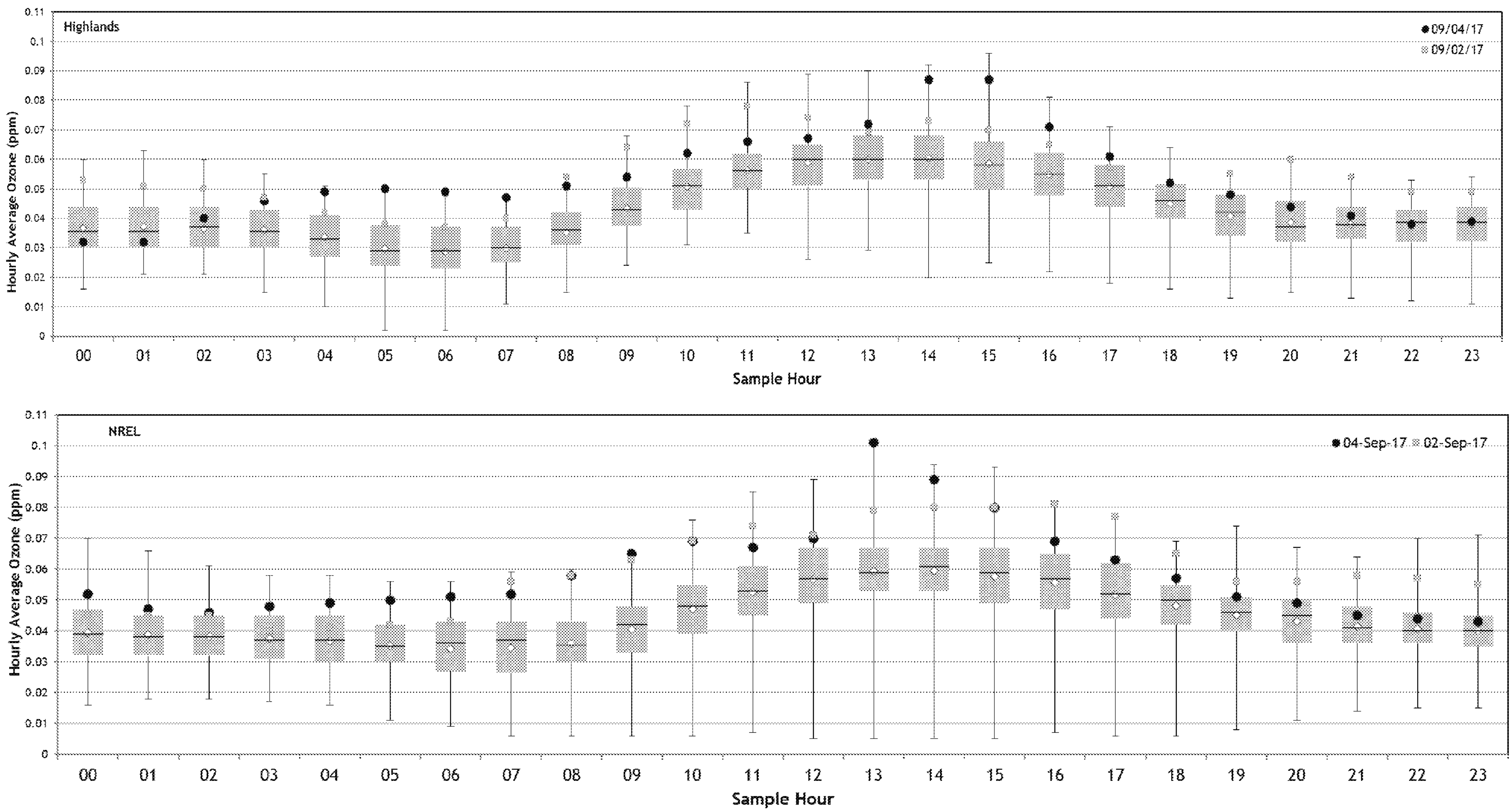
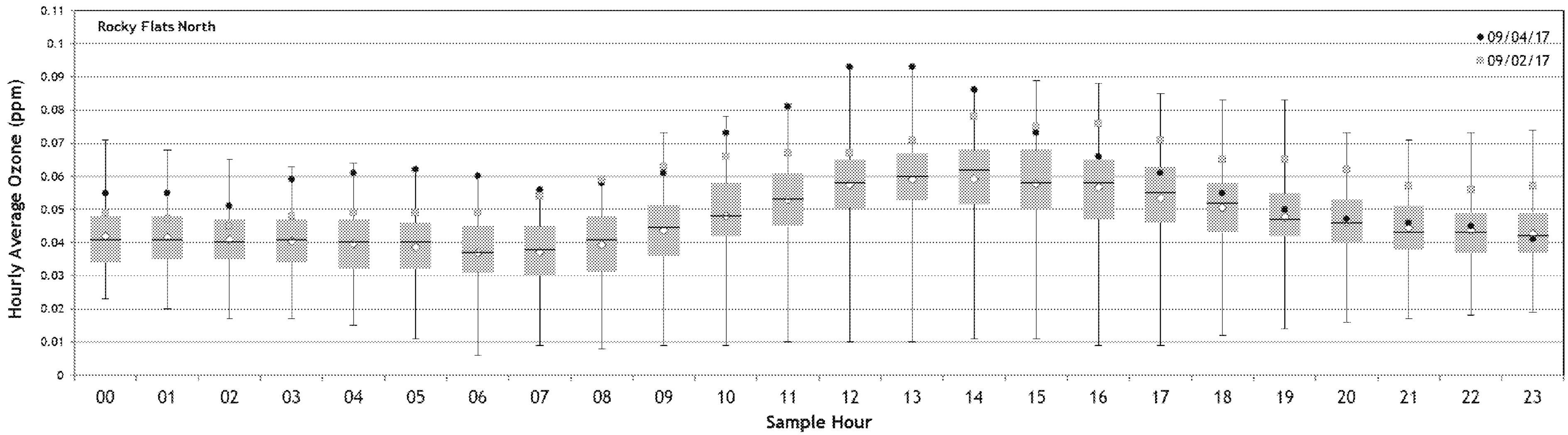


Figure 53: Diurnal Deviation from Normal Plots for hourly data at Highland (AQS ID 080050002) and NREL (AQS ID 080590011)



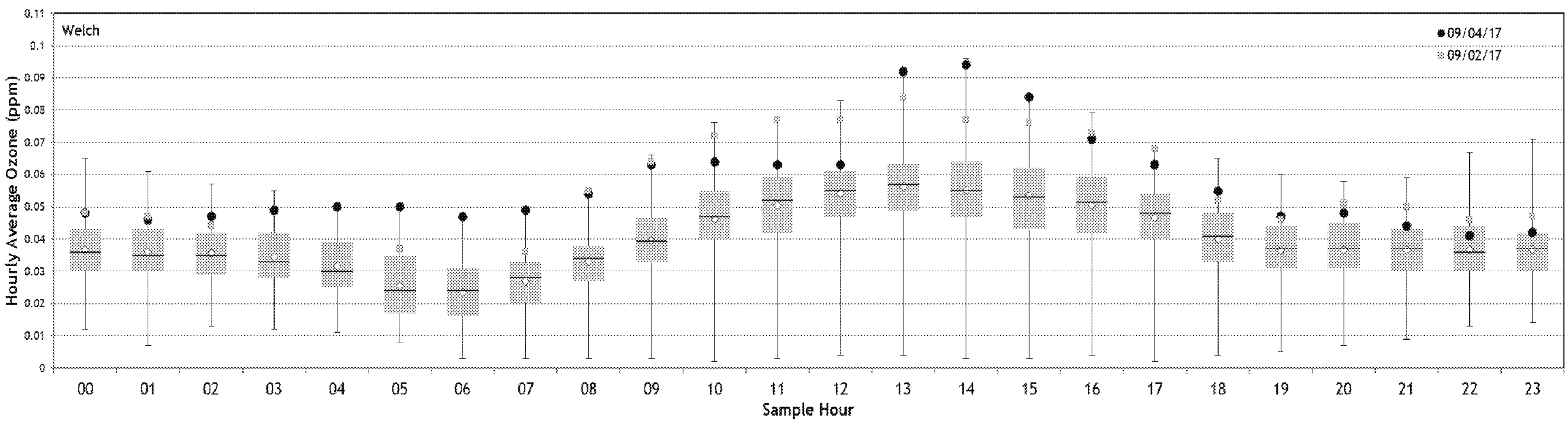


Figure 54: Diurnal Deviation from Normal Plots for hourly data at RFN (AQS ID 080590006) and Welch (AQS ID 080590005)

4.2.4 Historical Fluctuations of $PM_{2.5}$ Concentrations in the DM/NFR area

To demonstrate the $PM_{2.5}$ data for this event was affected by an exceptional event, APCD compiled summary tables and charts of $PM_{2.5}$ Federal Reference Method (FRM) data from DM/NFR area samplers using five years of data from 2013 through 2017. Data has been taken from those sites which have continuously operated a FRM sampler for the entire period. The APCD has been monitoring $PM_{2.5}$ concentrations in these areas since 1999. The samples values for the event(s) are presented in Table 18. The overall data summary for the affected sites is presented in Table 19; all data values are presented in µg/m^3:

Table 18: FRM Sample Values September 2017

	ACC	Longmont	Boulder	CAMP	La Casa	Chatfield	Platteville
9/2/2017	n/a	n/a	n/a	24	n/a	n/a	n/a
9/4/2017	37.5	54.8	48.8	44.9	44.1	38.9	52.4

Table 19: 2013 - 2017 FRM Data Summary, Affected Sites

	ACC	Longmont	Boulder	CAMP	La Casa	Chatfield	Platteville
Average	6.1	6.9	5.7	7.2	7.2	5.3	7.6
Median	5.1	5.6	4.8	6.2	6.05	4.6	6.3
StDev.	4.0	5.4	4.3	4.5	5.0	4.2	5.6
Range	36.2	54.1	48.1	45.8	44.3	44.2	51.8
Min	1.3	0.7	0.7	0.5	1	0.7	0.6
Max	37.5	54.8	48.8	46.3	45.3	44.9	52.4
Count	569	570	576	1675	574	560	533

A snapshot summary of data from all sites affected by the event(s) is presented in Table 20, along with the approximate percentile value that each data point represents for each site within their unique historical data sets, for the month of the event (every sample in any September), and for the year of the event. All percentile calculations presented in this section were made using the entire 2013 - 2017 dataset. The sample value from CAMP on September 2, 2017 of 24 µg/m^3 was the only FRM sample available on that day. That value is the 2nd highest sample in any September, and exceeds the 99th percentile for the entire data set. Percentile calculations for some DM/NFR area sites affected by the event are presented in Table 20.

Table 20: Site Percentile (All Affected Front Range Sites)

Evaluation	*ACC*	*Longmont*	*Boulder*	*CAMP*	*La Casa*	*Chatfield*	*Platteville*	*CAMP (9/2)*
9/4/2017	37.5	54.8	48.8	44.9	44.1	38.9	52.4	24
Overall	Max	Max	Max	99.8	99.8	99.8	Max	98.8
Any Sept.	Max	Max	Max	Max	Max	Max	Max	99
2017	Max	Max	Max	Max	Max	Max	Max	98.8

The samples from the Front Range sites are exceptional within their own datasets for any evaluation criteria. The overall magnitude and broad geographical extent of affected sites suggests that there was a common contribution to each sample from sources beyond that contributed by local sources.

In addition to the sites equipped with FRM samplers a number of sites with FEM continuous samplers were impacted over this interval. Figure 56 presents a time series of those continuous sites equipped with an FEM sampler for seven days prior to September 2 and seven days after September 4. Note the spikes on September 4 and the elevated values on September 2 from sites spanning the DM/NFR area, with discussions of three area sites below.

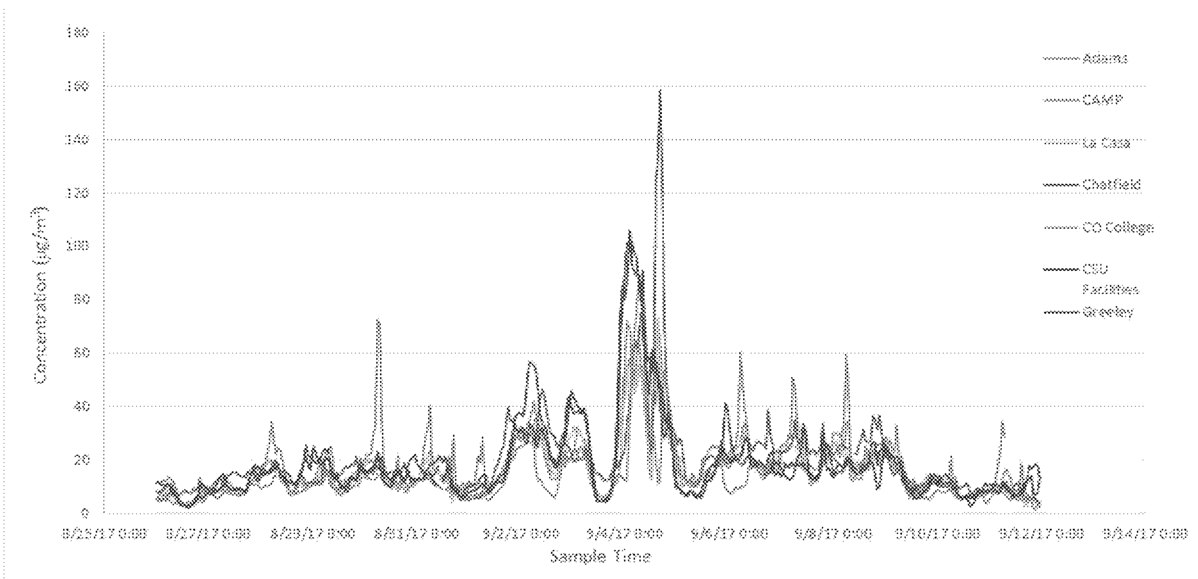


Figure 55: Front Range Hourly PM$_{2.5}$ Concentrations

Platteville - 081230008

The $PM_{2.5}$ sample on September 4, 2017, at Platteville of 52.4 $\mu g/m^3$ is the largest sample recorded among all September samples, is the maximum value for all 2017 data, and is the largest sample value for the entire dataset of 533 samples. The sample of September 04 clearly exceeds the typical values for this site.

The following graph characterizes the Platteville $PM_{2.5}$ data and demonstrates the extent to which the event sample is exceptional. Figure 57 is a box and whisker plot of all FRM samples from 2013 through 2017; the sample from September 4 is identified.

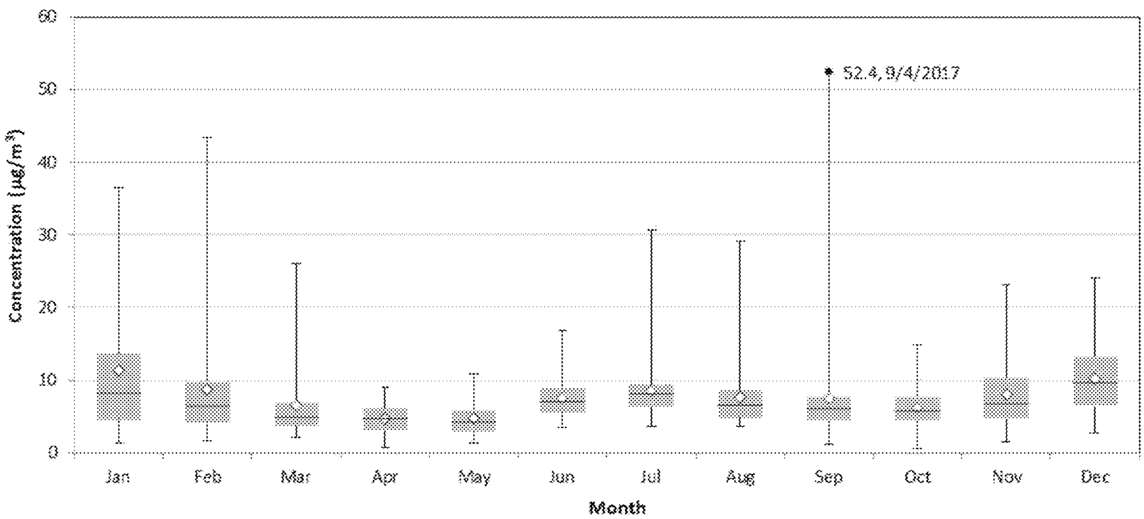


Figure 56: Platteville $PM_{2.5}$ Box and Whisker Plot

The monthly box-whisker plot highlights the typical seasonal variation of $PM_{2.5}$ samples at the Platteville monitoring site. Note the limited variability (narrower inter-quartile range) of the data through the summer and early fall months. Typically, samples from this time are low relative to those in the winter and early spring, taken during conditions typified by temperature inversions.

CAMP - 080310002

The $PM_{2.5}$ sample on September 4, 2017, at CAMP of 44.9 µg/m^3 is the largest sample recorded among all September samples, is the maximum value for all 2017 data, and exceeds 99% of all samples of the entire dataset of 1,675 samples. The sample of September 4 clearly exceeds the typical samples for this site. The sample of September 2, 2017 is the 2nd largest sample recorded among all September samples, is the 4th largest from 2017, and exceeds 98% of the entire dataset. While not as extreme as the September 4 sample, it clearly exceeds what is typical for this site.

The following plot graphically characterizes the CAMP $PM_{2.5}$ data and demonstrates the extent to which the event sample is exceptional. Figure 58 is a box and whisker plot of all FRM samples from 2013 through 2017; the samples from September 2 and 4, 2017 are identified.

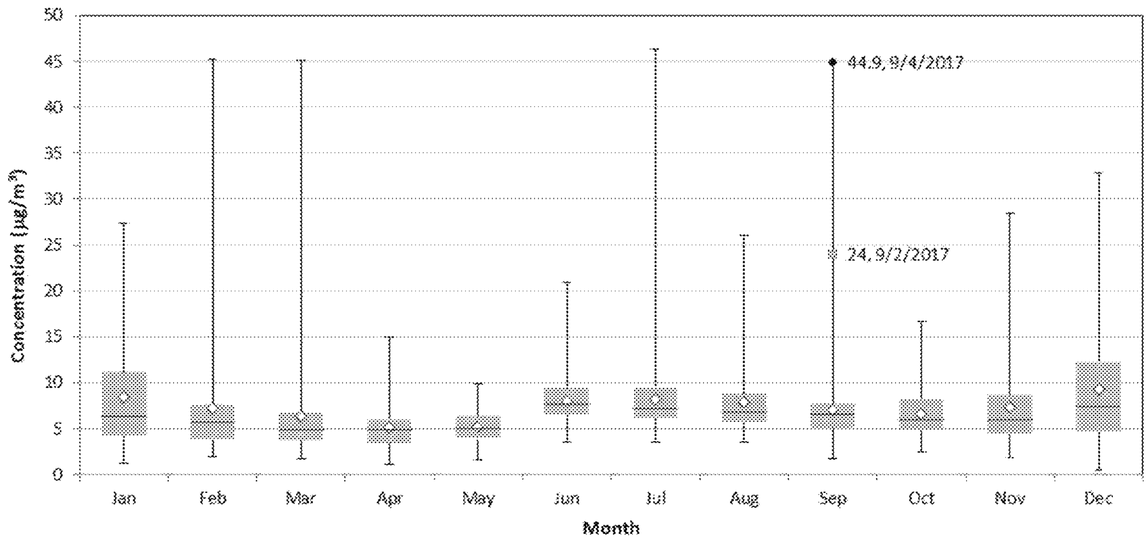


Figure 57: CAMP $PM_{2.5}$ Box and Whisker Plot

The monthly box-whisker plot highlights the typical seasonal variation of $PM_{2.5}$ samples at the CAMP monitoring site. Note the limited variability (narrower inter-quartile range) of the data through the summer and early fall months. Typically, samples from this time are low relative to those in the winter and early spring, taken during conditions typified by temperature inversions.

Chatfield - 080350004

The $PM_{2.5}$ sample on September 04, 2017, at Chatfield of 38.9 µg/m^3 is the largest sample recorded among all September samples, is the maximum value for all 2017 data, and exceeds

99% of all samples of the entire dataset of 560 samples. The sample of September clearly exceeds the typical samples for this site.

The following plot graphically characterizes the Chatfield $PM_{2.5}$ data and demonstrates the extent to which the event sample is exceptional. Figure 59 is a box and whisker plot of all FRM samples from 2013 through 2017; the samples from September 4, 2017 is identified.

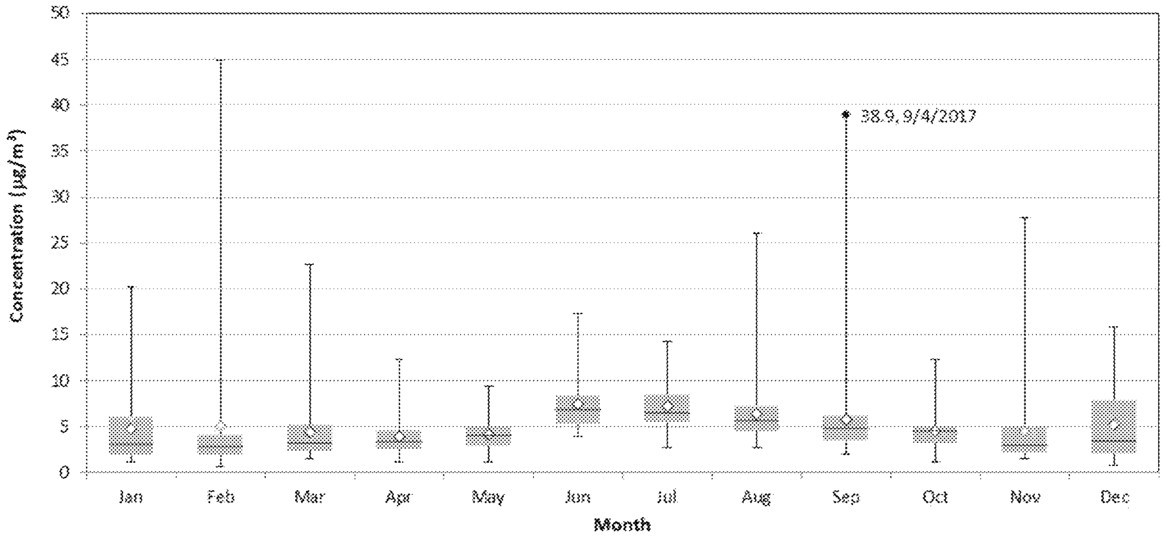


Figure 58: Chatfield $PM_{2.5}$ Box and Whisker Plot

The monthly box-whisker plot highlights the typical seasonal variation of $PM_{2.5}$ samples at the Chatfield monitoring site. Note the limited variability (narrower inner-quartile range) of the data through the summer and early fall months. Typically, samples from this time are low relative to those in the winter and early spring, taken during conditions typified by temperature inversions.

Historical Data Summary

Of the six monitors that the APCD is presenting as being influenced by a wildfire smoke exceptional event, on September 2, 2017:

- Three monitors met or exceeded the 99th percentile using six years of monthly September data from 2011-2016 [Chatfield (080350004), NREL (080590011), Welch (080590005)].

- Two monitors met or exceeded the 99th percentile using six years of 2-week data from August 26 to September 9 for years 2011 to 2016 [NREL (080590011), Welch (080590005)].
- Two monitors had event maximum daily 8-hour average rank order values in the top four positions using the previous one year of data from September 2, 2016 to September 4, 2017 [NREL (080590011), Welch (080590005)].
- Diurnal historical max hourly values were observed at Highland (080050002)(hours 19 to 21), NREL (080590011) (hours 16 and 17), RFN (080590006) (hour 8), and Welch (080590005)(hour 17) using data from August 26-September 9, 2013-2017.
- Elevated $PM_{2.5}$ values from select sites in the DM/NFR area support visual and meteorological observations that wildfire smoke was in the area.

Of the six monitors that the APCD is presenting as being influenced by a wildfire smoke exceptional event, on September 4, 2017:

- Five monitors met or exceeded the 99th percentile using six years of monthly September data from 2011-2016 [Aspen Park (AQS ID 080590013), Chatfield (AQS ID 080350004), Highland (AQS ID 080050002), NREL (AQS ID 080590011), Welch (AQS ID 080590005)].
- Two monitors met or exceeded the 99th percentile using six years of 2-week data from August 26 to September 9 for years 2011 to 2016 [NREL (AQS ID 080590011), Welch (AQS ID 080590005)].
- Three monitors had event maximum daily 8-hour average rank order values in the top four positions using the previous one year of data from September 2, 2016 to September 4, 2017 [Aspen Park (AQS ID 080590013), NREL(AQS ID 080590011), RFN (AQS ID 08059006)].
- Diurnal historical max hourly values were observed at Aspen Park (080590013) (hours 5,6,14,15,16, and 19), Chatfield (AQS ID 080350004) (hour 14), Highland (AQS ID 080050002) (hours 5,6, and 7), NREL (AQS ID 080590011) (hour 9 and 13), RFN (AQS ID 080590006) (hours 5, 6, 7, 12, 13, and 14 hrs) and Welch (AQS ID 080590005) (hours 4,5,6,7,13, and 15) using data from August 26 toSeptember 9, 2013-2017.
- Elevated $PM_{2.5}$ values from select sites in the DM/NFR area support visual and meteorological observations that wildfire smoke was in the area.

These events, when taken in their entirety and as summarized above, meet the criteria for key factor #2 as described in the Guidance and thus support this demonstration. The uncharacteristically high hourly and maximum daily 8-hour average O_3 concentrations, particularly in the presence of high $PM_{2.5}$ concentrations, and the exceptional spatial coverage of the event over the DM/NFR area, all suggest that the six monitors presented in this analysis were influenced by a wildfire smoke exceptional event and should be excluded from consideration in O_3 NAAQS determinations.

5.0 Caused by Human Activity that is Unlikely to Recur

According to the CAA and the EER, an exceptional event must be "an event caused by human activity that is unlikely to recur at a particular location *or* a natural event" The definition of wildfire in the EER is: "…is any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event."

Per 40 CFR 50.1(o), natural factors are principally responsible for wildfires on wildland (defined as "an area in which development is essentially non-existent, except for roads, railroads, powerlines, and similar transportation facilities. Structures, if any, are widely scattered."). Land within national parks, national forests, wilderness areas, state forests, state parks, and state wilderness areas are generally considered wildland. Land outside cantonment areas on military bases may also be considered wildland. Therefore, the EPA believes that treating all wildfires on wildland as natural events is consistent with the CAA and the EER. Since wildfires on wildland are treated as natural events, it is expected that minimal documentation will be required to meet the human activity that is unlikely to recur at a particular location or a natural event element.

Based on the documentation provided in Section 4 and Appendix B of this submittal, of the twenty-eight wildfires discussed in this in this petition, twenty-three were caused by lighting or a natural cause and four have an unknown cause, while all of the wildfires occurred on wildland.

The EPA generally considers the emissions of O_3 precursors from wildfires on wildland to meet the regulatory definition of a natural event at 40 CFR 50.1(k). The APCD has shown that the wildfire events occurred on wildland, qualify as natural events, and may be considered for treatment as an exceptional event.

6.0 Not Reasonably Controllable or Preventable

According to the CAA and the EER, an exceptional event must be "not reasonably controllable or preventable." The preamble to the EER clarifies that the EPA interprets this requirement to contain two factors: the event must be both not reasonably controllable and not reasonably preventable at the time the event occurred. This 14 40 CFR 50.1(o). 32 requirement applies to both natural events and events caused by human activities, however it is presumptively assumed that wildfires on wildland will satisfy both factors of the "not reasonably controllable or preventable" element unless evidence in the record clearly demonstrates otherwise.

Based on the documentation provided in Section 4 and Appendix B of this submittal, of the twenty-eight wildfires discussed in this in this petition, twenty-three were caused by lighting or a natural cause, four have an unknown cause, and all of the wildfires occurred on wildland. The APCD is not aware of any evidence clearly demonstrating that prevention or control efforts beyond those actually made would have been reasonable. Therefore, emissions from these wildfires were not reasonably controllable or preventable.

7.0 Public Comment

According to the provisions in 40 CFR 50.14(c)(1)(i), air agencies must "notify the public promptly whenever an event occurs or is reasonably anticipated to occur which may result in the exceedance of an applicable air quality standard." Appendix D provides the APCD Air Quality Advisories that were issued in response to this event. The Advisories were posted on the APCD website and social media accounts and distributed to the APCD air quality email lists. The Air Quality Health Advisory was forwarded to county level public health and environmental contacts in the affected counties.

In addition, according to 40 CFR 50.14(c)(3)(v), air agencies must "document [in their exceptional events demonstration] that the [air agency] followed the public comment process and that the comment period was open for a minimum of 30 days…." Further, air agencies must submit any received public comments to the EPA and address in their submission those comments disputing or contradicting the factual evidence in the demonstration.

The APCD posted notice of this exceptional event demonstration on [date posted] in the following counties/locations: [list counties affected and locations posted]. [Number] public comments were received and have been included in [Appendix D] of the demonstration, along with APCD's responses to these comments.

8.0 Conclusion

Numerous wildfires in the Pacific Northwest, Wyoming, Idaho and Montana generated high levels of O_3 precursors and O_3 concentrations that were transported into Colorado's DM/NFR area on prevailing winds. The wildfire emissions resulted in elevated concentrations at four O_3 monitoring sites on September 2, 2017 and six O_3 monitoring sites on September 4, 2017 in Colorado for a total of ten exceedances. The evidence presented in this document satisfies the exceptional event criteria: the event was a natural event, which affected air quality in such a way that there exists a clear causal relationship between the event and monitored exceedances, and was not reasonable controllable or preventable. APCD has also satisfied the procedural requirements for data exclusion. The APCD requests that EPA Region 8 concur with this exceptional event demonstration and exclude the O_3 monitoring data requested in this document.

9.0 References

United States Environmental Protection Agency, 2016. Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations, Final. [Available online at: https://www.epa.gov/sites/production/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf]

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Reddy P.J., and Pfister, G.G., 2016. Meteorological factors contributing to the interannual variability of midsummer surface ozone in Colorado, Utah, and other western US states. Journal of Geophysical Research: Atmospheres 121 (5), 2434-2456.